THE ENGINEERING RECORD

Published Weekly by the

McGraw Publishing Company

James H. McGraw, Pres.; Curtis E. Whittlesey, Sec. and Treas.

MAIN OFFICES:
239 West 39th Street, New York.

BRANCH OFFICES:
Chicago: Old Colony Building.
Philadelphia: Real Estate Trust Building.
Cleveland: Schofield Building.
San Francisco: Atlas Building.
London Office: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.

United States, Cuba and Mexico	$3.00 a year
Canada	$4.50 a year
Foreign subscription	$6.00 a year

25 shillings. 25 marks. 31 francs.

Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of The Engineering Record on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

Remittances.—Remittances should be made by check, New York draft, or money order, in favor of The Engineering Record.

Changes of Address.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

Back Copies.—No copies of issues prior to July, 1906, are kept on sale, except in bound volumes.

Date on Wrapper indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

Club Rate.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. The rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1907, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 14,500 copies are printed. Total circulation for 1907 to date, 626,000 copies, an average of 14,588 copies per week.

TABLE OF LEADING ARTICLES.

The Status of Wireless Telegraphy.............. 443
Heating and Ventlation Tests.............. 443
The Great Inland Waterway.............. 444
The Engineering Record's New Home.............. 445
An Unusual Plant for Constructing a Submarine Tunnel (Illustrated).............. 446
Harbor Work at Huron, Ohio (Illustrated).............. 450
The Erection of the Moodna Creek Viaduct (Illustrated).............. 451
Favorable Report on Calumet Drainage Canal.............. 453
Sinking Viaduct Piers with Hydraulic Jacks (Illustrated).............. 454
The Reinforced Concrete Work of the McGraw Building (Illustrated).............. 455
An Ornamental Foot Bridge in Bronx Park.............. 460
Gas-Power Central Station of the Duquesne Light Co., Pittsburg, Pa. (Illustrated).............. 460
Three Low-Head Hydro-Electric Developments in Michigan—Part II (Illustrated).............. 462
Heating and Ventilating the Commercial National Bank Bldg., Chicago—Part I—(Illustrated).............. 466
The Benguella Railway, Africa.............. 466
Soft-Coal Producer Plant at Pasco, Wash. (Illustrated).............. 468
Book Notes.............. 469
Misuse of Derrick Cars.............. 470
Conditions on the Isthmus of Panama.............. 470
Impermeable Concrete.............. 470

The Status of Wireless Telegraphy.

The other day, with a considerable and not unjustifiable blare of trumpets, it was announced that the Marconi transatlantic service was definitely established between the Port Morien and Clifden stations, the former near Glace Bay, the latter on the coast of Ireland. From this time on, it is stated, the wireless system will be in regular competition with cable service. At this point in the history of wireless it may be well to run over some past happenings to gain thereby some idea as to the real status of the art, and some notion of its usefulness in the immediate future. Far be it from this journal in any way to dim the lustre of William Marconi's achievements; he deserves well of the world as the practical pioneer in a new art. Yet it cannot be denied that wireless telegraphy as a whole has not yet fulfilled the promise of its beginnings and has at times been a grievous disappointment. The Engineering Record hopes that this latest effort marks the beginning of a period of uniform success and only occasional failure, instead of rather uniform failure enlivened by brilliant and inexplicable successes.

Wireless telegraphy has had in its short life a singularly checkered career. Nothing more uncanny and weird than this system of annihilating space had ever dawned upon the world save the lurid and cometary blaze of promotion which has followed in its trail. It is now more than five years since the first alleged transatlantic messages flashed across the speculative horizon. Just what really happened at this period few know and none are likely to tell for years to come. It seems to be well established that signals from shore to shore were actually transmitted and received, but there were disquieting rumors of the use of the old reliable cable for the messages of congratulation which have never been adequately disproved.

Whether connected messages via wireless were received at this time or not, it is certain that their transmission was little better than fortuitous. It is simply unthinkable that even a moderate regularity of success would not have promptly been followed by some serious effort at doing business, with a less delay than five years at least. Instead, there have been dismal failures of wireless transmission, at very moderate distances even over water, failures that do not of course score heavily against the future of the method, but merely show that the art is not yet upon a sufficiently sound theoretical basis to eliminate the frequent interference of the unforeseen. Mingled with these there have been brilliant successes, at times by all the varieties of the wireless systems in vogue. The cruise of the "Carlo Alerto" did much to restore the confidence that had been shaken by the first transatlantic fiasco, by proving that readable messages could cover distances at least comparable with the width of the Atlantic. Later installations on naval and merchant vessels have co-operated with shore station in some very long transmissions rising at times to a couple of thousand miles and more, although not with much regularity. It has not been unusual of late for an Atlantic liner to keep in touch with one shore or the other throughout her voyage. Most attempts at wireless working have been greatly handicapped by quite insufficient energy supply, and there is every reason to suppose that increasing the available power as Marconi has done in his recent stations will enable the reliable range of transmission to be greatly increased. Whether he has increased this range to the width of the Atlantic the trials now in progress will presently prove. When business men settle down to using the system as an ordinary means of communication its success will be firmly established, and that may be within a very short time.

It is hard to set a limit to the applicability of wireless in view of the distances that have already been covered. The most serious practical question at present is that of interference. Each wireless system has made its claims of syntonic operation, but The Engineering Record does no conscious injustice to anyone in saying that such claims have not yet been shown to rest upon any firm foundation. Interference has been the practically invariable rule whenever two systems have been within reasonable striking distance of each other. It would be interesting, for example, to know the truth about the colossal hoax which was apparently perpetrated on Marconi the other day in the alleged message intercepted from Manila announcing the safe arrival of the U. S. S. Philadelphia, which worthy craft has been securely moored in Puget Sound for the last three years. It is altogether reminiscent of the famous dispatch from Major Reflipe W. Thenuz perpetrated during the Spanish war. So long as the longest practicable waves are necessary to carry the energy sufficient for a long transmission, and everyone undertaking long distance work must push toward this limit of practicability, there seems to be no reasonable chance of avoiding interference. Something could perhaps be done were all wireless stations worked as a harmonious whole with spheres of influence connected in definite ways, but at present this unity is very far from being secured. This much is certain, however, that at the present time wireless telegraphy can, if systematically utilized, make all the seas familiar ground. It would be well within the range of feasibility to net the earth with international stations so disposed that no ship could be out of instant touch with shore. For instance, the Atlantic could be easily covered from Newfoundland, Bermuda, Barbadoes, the Cape Verde Islands, and the Azores in the northern waters, and Ascension, St. Helena, Trinidad and Tristan d'Acunha in the southern, co-operating with shore stations. Such a conquest of the waters would be of vastly greater solid benefit than any of the sensational feats which are so tempting to the imagination. Meanwhile success to Marconi in his present efforts and may he fully succeed!

Heating and Ventilation Tests.

It is doubtful if any branch of mechanical engineering practice offers a more fertile field for investigation at the present time than heating and ventilation. The design of an important installation of this character involves many assumptions as to the leakage coefficients, radiation losses, and aid friction expected; and while a great deal of excellent work is being done in this line, as the results in many installations show, there is certainly need of more definite knowledge of the conditions which insure success or failure in specific plants. Taken in itself the heating problem is much less difficult to solve in most cases than the securing of good ventilation, but the two are bound so closely together that they ought not to be considered separately either in designing or testing the performance of individual plants. Failure to appreciate the particular conditions of plants from both standpoints has injured the reputation of heating and ventilating practice not a few times in the judgment of the general public, which estimates the performance of an installation by its personal feelings and comfort rather than by quantitative tests.

In a branch of engineering where so many uncertainties are involved, or at least so many assumptions, the accumulation of a large quantity of test data is essential, beyond the usual extent, to the harmonizing of theory and practice. Many engineers are collecting this kind of information for their own private use, and of course much of it is rightly considered as personal stock in trade. At the same time, there is great need of bringing the technical considerations of the work down to a more generally available form, and the presentation at this time of two or three exhaustive paper by men in practice on specific problems in heating and ventilation, either in the technical press or before the engineering societies, would stimulate progress and be widely helpful in breaking down the eccentricities of a highly individualized practice. No matter how fully data may be published, on complex work of this kind, the value of judgment can never be replaced by the mere possession of formulas and constants. The right use of the latter with knowledge of their limitations must invariably be largely settled by experience. When these are supplemented by tests, real progress lies close at hand.

The range of tests possible in a heating and ventilating installation is very broad, and in many commercial instances only the fundamental issues can be determined. The quantity of air supplied per capita per hour, the quality of the supply and the temperatures obtained in the principal rooms are essential to any proper appreciation of the working of an installation. Combined with these factors in the comfort of the users of the premises is the question of operating economy, expressed more or less indirectly by the size of the coal bills. It is quite as important to keep a daily log of the heating plant as to prepare and submit regular operating records of a power installation to its owners, though in many quarters this is not yet fully realized.

As soon as one begins to measure the quantities required in a heating and ventilating test he must realize that scientific accuracy is a very difficult thing to secure. Temperature measurements can, of course, be carried to great refinement, if desired, but accurate determinations of air velocity and volume are not easy to make. An error of even 2 or 3 per cent. in the velocity measurement means the inclusion or exclusion of a large volume of air when multiplied by a considerable duct area in a building seating several thousand people. The calibration of anemometers is sometimes attempted by timing with a stop watch the speed of an observer traversing a known distance with an instrument in his hand, but it is a question if such a calibration can be relied upon to any considerable extent. Certainly for an accurate test upon a plant moving scores of thousands of cubic feet of air per minute, the anemometers used should be calibrated by physical laboratory methods. In some tests air velocities measured in one or two representative ducts have been taken as bases of operation throughout the entire installation, particularly where the ducts are not readily accessible. Such assumptions are dangerous to make if accurate figures are desired, and in any test carried out thoroughly as far as it goes, the data secured will show the velocity of air at every outlet which is essential to the proper operation of the system installed.

Fan speeds measured with a tachometer and not taken from the manufacturer's name plates are equally essential. One of the most important interpretations to be made from a heating and ventilating test when forced or induced draft is employed is the relation of fan speed to the volume of air delivered. Even if the exhaust from the fan engines be delivered to the indirect heating coils, the supply of the necessary quantity of air per capita per hour calls for the adjustment of fan speeds in relation to the external temperature and weather conditions; and in the case of variable speed motor-driven fans, the saving in power gained by not operating at abnormal speeds in relation to the requirements is well worth securing.

Air discharges in outlet ducts furnish helpful data in almost every case where the test is carefully made. The effect of damper adjustments, both automatic and manually operated, is interesting to study in a concrete installation, especially in plants where mixing dampers are in service. In this connection, the sensitiveness and speed of automatic themostat control deserve more attention than they ordinarily receive. In tests of refrigerating systems the response of the regulating valves to slight changes in temperature is almost always carefully watched, and no less of a working examination should accompany a heating test, whether the test be on a newly completed or a long established installation. Complete temperature readings in all the vital portions of a heating and ventilating system are imperative if correct deductions are to be made. The mean of several readings per duct or per room is none too good an index of the varying conditions to be expected in practice.

For the majority of cases the purity of the air can be sufficiently well determined by the phenoephthalein lime-water test, in which the time required to eliminate the pink color in a carefully prepared solution is noted when the solution and the air sample are brought into intimate contrast. According to Coyne's method, this time with a properly prepared solution is indirectly proportional to the amount of carbon dioxide present. Nothing short of a chemical analysis will show the accompanying atmospheric impurities in an air sample, but in the absence of any fixed standard of impurity other than the carbon dioxide figure, this simple test is doubtless acceptable enough for all but the most disputed cases. No heating or ventilating system can eliminate the dangers of atmospheric pollution from bacteriological causes, but in securing the presence of a low percentage of carbon dioxide the engineer helps to keep the standard of vitality at a high point per capita. Hence no test of the general value of a heating and ventilating system is complete without careful approximate measurements of the carbon dioxide present. The cleanliness of the air supply is well worth noting in such tests, by reference to scrubbing and washing apparatus when the installation contains such equipment.

On the heating side the most thorough study of a plant calls for an evaporation test on the boilers, with separate calorific determination of the fuel, and close checking of weights before the efficiency of steam application can be known. Given these boiler data and knowing the heat distributed in the steam supply, a fair check upon the efficiency can be obtained by weighing the returns and noting their temperature on the feed water side of the system. Where the run of piping through tunnels or walls is considerable before the direct radiators are reached, it may be necessary to make separate tests of radiation losses on known lengths of pipe in order to make the necessary deductions from the total heat units supplied to the distributing system. Where both direct and indirect radiation are tested at the same time it is necessary to separately measure the effect of changes in each system if the performance of either is desired in detail.

It is evident upon very limited consideration that the range of quantities and inter-relations open for actual research in heating and ventilating systems is almost unparalleled in the field of mechanico-physics. In the preceding paragraphs only the more important quantities and measurements have been mentioned. The working out of heat losses in detail, the study of the heat conducting and radiating characteristics of different types of apparatus, and of varying forms of wall, ceiling and floor construction, the analysis of resistance in ducts as affected by curves and elbows, the study of air leakage under different conditions of weather, and the consideration of fuel consumption in relation to the plant design and conditions of operation, furnish ample scope for research activities. Still another reason for the practice of heating and ventilating tests is to make sure from time to time that the installation is being handled as well as possible. It frequently happens, especially in school houses and other public buildings, that while a heating plant may start in economically, changes in the use of rooms, alterations in the buildings, or sometimes corrupt political practices place burdens upon the system which it was never designed to meet. The light which a test by a responsible engineer throws upon the conditions obtaining in a heating plant often points the way toward radical economies, either in the purchase and use of fuel, or the handling of the plant itself.

The Great Inland Waterway.

An unusual role has been played in the history of Chicago by zoological circumstances. For a considerable time many residents of the inland metropolis were accustomed to consider the proper representation on the city's shield to be a cow rampant, surmounted by a kerosene lamp. But it looks now as though this familiar blazon must be exchanged for an ursus couchant, for our honored chief magistrate, having at last found and slain that bear in the Louisiana canebrakes, has emerged from his seclusion, elated and happy, to tell the people of Vicksburg that no American president could spend his time better than by seeing for himself just what a rich and wonderful region the lower Mississippi Valley is. He has also acquired the "set purpose to do everything that in me lies to see that the United States does its full share in making the Mississippi River a part of the sea coast, in making it a deep channel to the Great Lakes from the Gulf." In the study of the subject which he evidently gave it in company with the engineering specialists who assembled to conduct the siege operations of bruin, he ascertained that with one-tenth of the effort spent by the people of Holland in taking two-thirds of their country out from under the ocean, the United States can remove the incomparably rich bottom land of the lower Mississippi from all fear of flooding by the Mississippi River, by a high and broad levee system. The matter is settled, moreover, that the deep channel and the high and broad levees shall be built. The president intends to start the project on principles that will prevent mistakes, extravagance and misapplication of effort. "I shall have no small difficulty in persuading some people," he stated at Vicksburg, "of the wisdom of a policy such as that I advocate, a policy that means the expenditure of money, a policy which must continue over a long course of years. If that policy is tainted in any way by jobbery or folly, it will be immeasurably more difficult to carry it through. What we must look out for is the action of the men, probably well-meaning, who in their anxiety to serve some particular district, will try to divert what should be a national effort to deepen a great national highway into a succession of efforts spread out so thin as to make all ineffective."

It is instructive, indeed, to observe the energy with which our honored chief magistrate has thrown himself into the cause of a deep waterway from the Great Lakes to the Gulf. The fact that the majority of leading engineers of the country are by no means convinced of the desirability or even the actual financial practicability of such an undertaking apparently has no influence in checking his unqualified support of the project. The mere fact that it seems to lack this support from those most competent by training to appreciate the problems involved and the interests to be served by an enlarged channel will doubtless render the president's help extended to the advocates of the undertaking more vigorous and outspoken. We have all observed the great fondness he has displayed toward minority engineering opinions. And the fact that the desirability of a deep waterway from Chicago to the Gulf is at the present time advocated mainly by those who are least competent by training to express an opinion on the subject, or else by those who have an axe to grind, will doubtless be taken as merely an indication of the necessity of an educational campaign on his part.

In making these observations, there is no intention of asserting that an improved waterway from the Great Lakes to the Gulf will not be useful. It goes without saying that some use would be made of such a channel immediately upon its completion. The question at issue is whether the channel will be worth the expense, and, so far as The Engineering Record has yet been able to learn, there is no proof that money spent for a 14-ft. channel would not be about as well used in providing a game preserve near the White House. But this does not mean that a thorough study may not indicate the desirability of some kind of improvement. If the president's advocacy of a deep channel results in a thorough study, it will have been a national service. If that study is made by competent men, who are unbiased by the complications involved in the disposal of the sewage of Chicago by the method of dilution, the country will be thankful indeed. At the present time it seems hardly possible to differentiate between the people who desire to have a waterway for the purpose of navigation and those who believe that in some way or other the Trustees of the Chicago Sanitary District should be allowed to take a large amount of water from the Great Lakes for the disposal of the sewage of the community about the end of Lake Michigan.

Elsewhere in this issue will be found a summary of an important report made by Mr. Rudolph Hering, who designed the Chicago drainage canal, to the Trustees of the Sanitary District advocating the extension to the Calumet region of the method of disposal by dilution which the Trustees desire. He states that the anticipated lowering of the water lake level due to the diversion of the 14,000 cu. ft. per second from the lower end of Lake Michigan into the two canals for sewage disposal purposes will not occur, provided the works advocated by the International Waterways Commission are constructed at Sault Ste. Marie. This opinion is a direct contradiction of that reached by the members of the International Waterways Commission. The question is therefore thrown open to debate and the president is faced with the necessity of deciding between an international engineering commission representing the Dominion of Canada and the United States, and an individual engineer. Even assuming that the figures made by Mr. Hering are correct, and this journal does not attempt to pass an opinion on this disputed matter, the president must decide whether the desirability of permitting the city of Chicago to continue the use of a method of sewage disposal which is unnecessary although it may be financialy advantageous, is to outweigh the desirability of increasing the navigable depth of water throughout the Great Lakes, for if water is not diverted for the disposal of Chicago sewage, it will manifestly be available for improving the navigation from Chicago to Buffalo. The problem, therefore, is merely one of the relative interests served by the two methods of using the water.

Along with the disposal of the Chicago sewage, must also be considered the practicability of using for navigation this water turned into the drainage canals. It is fairly well recognized that the hope of sea-going vessels using the proposed waterway from Chicago to the Gulf is founded more on dreams than facts. The type of vessels which are best adapted for sea-going navigation and for use on inland waters are so radically different that the most to be expected from such a proposed channel is a growth of the fleet of shallow-draft vessels now using the Mississippi and its tributaries. Until more facts are ascertained than are now known, any arguments regarding the transportation possibilities of such vessels in competition with railway lines must inevitably be based on so many assumptions that the time spent in making or listening to them will be very largely wasted. Those who believe that a great waterway is needed from the Gulf to the Great Lakes will do more for this cause by securing all definite information bearing on the subject than by indulging in generalities. The cost of such a waterway is so enormous and its construction will extend over such a long period of years that the nation ought, under no circumstances, to be committed to it until every phase of the subject has been thoroughly investigated by competent, unbiased specialists.

The Engineering Record's New Home.

Elsewhere in this number will be found a brief description of the structural features of the new home of The Engineering Record. Many requests for information concerning this building have been received during the past year, but on account of the novelty of some of the details of the design and the special conditions which arose during the preparations of the plans for the structure, it was considered best to defer any detailed description for a paper for the American Society of Civil Engineers. This paper has been written by Prof. Wm. H. Burr, who designed the structural portion of the building, but there are certain comments which should be made in amplication of it. The structure, which is known as The Thirty-Ninth Street Building, was erected by a subsidiary corporation of the McGraw Publishing Company, the owner of The Engineering Record. Its primary purpose is to afford a home for the company and its affiliated printing corporation. Until the structure was erected and occupied, the printing of the company's various publications and books was done in three independent printing offices, and many difficulties are inherent in any such method of issuing large journals every week in editions equal to those of the McGraw publications. By bringing the printing, accounting, business, editorial and advertising departments of the company into a single building, the service that can be rendered by the company is materially bettered. To raise this service to the highest practicable degree it was desirable to have a structure readily reached from all parts of the city where engineers, contractors, city departments and manufacturers' offices are located, and it was equally desirable to have this building near the branch postoffices where second-class or "newspaper" mail matter is received. This narrowed the selection of a site materially and finally resulted in the selection of land on West 39th St., within about three minutes from Times Square, one of the central points of the city. This location is very near the new terminal station of the Pennsylvania R. R. now under construction, and also the Grand Central Station of the New York Central Lines, at both of which places mail matter of the second-class is either received now or will be received. The McGraw Realty Company has also arranged for the use of one floor and part of another floor of the new building as the "Times Square Sub-Station" of the New York Post Office, so that under its own roof there will be excellent facilities for expeditious handling of all mail matter other than that of the second class.

The site selected for the structure is an expensive one and the property in the vicinity is rising with great rapidity. In consequence of this condition ordinary business prudence made it advisable to erect a large building of an attractive appearance, well provided with the customary facilities of a modern office building. Three floors of the building must be occupied by the printing plant, and as the running of rotary presses is likely to cause vibrations, the design of the structure had to provide for the deadening of all such tremors. After an examination of many buildings containing printing presses, it was evident that a steel-cage structure of the height of the proposed building, about 150 ft., would probably tremble while the presses were running more than was admissible in a high-grade office structure, while a reinforced concrete building would probably be free from such vibration. A building of reinforced concrete, which is able to carry such loads as those imposed by printing plants on many of its floors, has to be of unusually heavy construction, and the mass due to the use of so much concrete acts in an efficient manner in absorbing vibration.

After the preliminary plans were worked out, it was found that a structure of the kind best adapted for the desired height could not be erected under the existing building requirements and be a good business proposition, so it became necessary to take up with the Bureau of Buildings the problem of designing columns which would be satisfactory to the Bureau and at the same time be of sufficiently moderate cross-section to leave enough room in the lower floors to render the latter useful for business purposes. Under the old regulations of the Bureau very large columns would have been required, and the proposed structure using such columns would have been a business impracticability. Probably the most interesting feature of the building is the type of columns finally adopted, which is fully described in Professor Burr's paper.

Another feature of the structure to which attention may be called is its exterior. Objections have been raised to the use of concrete in buildings on account of the impracticability of giving it a satisfactory exterior appearance. In some structures in New York this alleged defect has been avoided by using brick facings, and in buildings elsewhere the concrete surface itself has been treated in various ways more or less satisfactory. The Thirty-Ninth Street Building had to be as attractive as possible, and after a prolonged study it was finaly determined to use a sort of stucco of Portland cement and marble dust, which has been employed very successfully for several years in the vicinity of New York. This is a comparatively new proprietary process and the results of its application in The Thirty-Ninth Street Building are very satisfactory. At the present time the building is not entirely completed in some of the minor details, and it is undesirable in consequence to publish at this time illustrations of its appearance now. It may be stated, however, that the expectations of the company concerning it are fully met, and the many novelties, large and small, which were adopted on the advice of Professor Burr and his associates have proved uniformly satisfactory. While the structural novelties are explained in the paper in this issue, the general appearance of the building, the admirable lighting of the various floors on account of the unusual window space and other features which need not be mentioned at this time can only be appreciated by a personal visit, which the company cordially invites all its friends to pay to its new home.

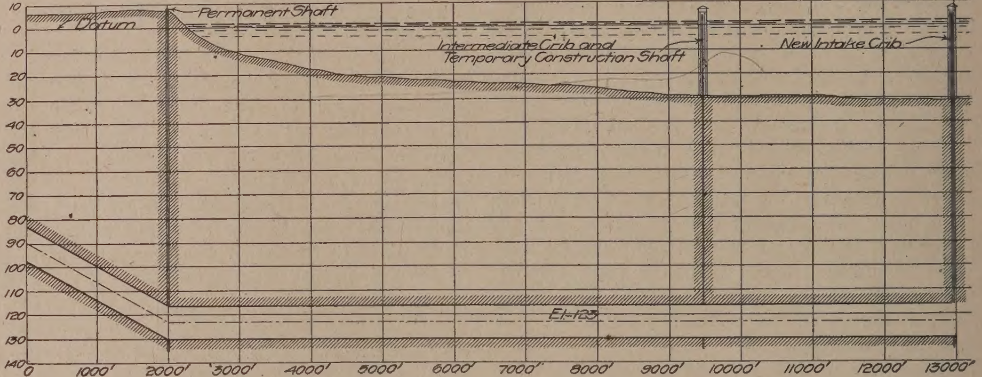
AN UNUSUAL PLANT FOR CONSTRUCTING A SUBMARINE TUNNEL AT CHICAGO.

A noteworthy installation of contractor's plant has been placed in service recently by George W. Jackson, Inc., in connection with the construction of the lake section of a new tunnel for the water-works system in Chicago. This tunnel, generally known as the Southwest Lake and Land Tunnel, is to have a total length of approximately 10 miles, extending from an intake crib about 11,000 ft. off-shore in Lake Michigan from 68th St. to the southwestern part of the city. The intake crib of the new tunnel is adjacent to the intake crib of an existing water tunnel which leads to a pumping station near the foot of 68th St., the shore end of the lake section of the new tunnel being at the foot of 73d St. Based on experience in the construction of the 68th St. tunnel, and on a number of borings made prior to the location of the new tunnel, it is expected that the latter will be entirely in limestone bed rock. The finished cross-section of the tunnel will be a 14-ft. circle for about 2¼ miles from the intake crib to a point where a 9-ft. branch is taken from it. From this branch the section will be reduced to a 12-ft. circle, which continues for some distance to a division of the tunnel into two 9-ft. branches. The tunnel is to be lined throughout with concrete, which is to have a minimum thickness of 1 ft., so the excavation for the lake section is required to be at least 16 ft. in diameter, and involves the removal of something over 125,000 cu. yd. of solid rock from the tunnel bore.

The center line of the land sections of the tunnel are 100 to 110 ft. below the ground surface, the latter being only 8 to 10 ft. above the mean water level in the lake. The tunnel drops on a 1.75 per cent. grade for 2,000 ft. adjacent to the lake, and then continues on a level grade in the lake section, the center line of this section being at a uniform depth of 123 ft. below the mean lake level. The section, which is being constructed by Geo. W. Jackson, Inc., has a total length of 12,180 ft., about 10,800 ft. of which is off-shore under the lake. A permanent shaft, 14 ft. in diameter inside the concrete lining, is placed at the point where the grade of the tunnel begins to rise, approximately 300 ft. from the shore of the lake. The intake crib at the outer end of the tunnel, which is also included in the contract, will be connected with the tunnel by a shaft, 11 ft. in diameter inside the concrete lining.

The lake section of the tunnel will be driven from at least four headings, one in each direction from the foot of the permanent shaft near the edge of the lake, and one in each direction from a temporary construction shaft, 7,500 ft. off-shore. It is also probable that some tunnel driving will be carried landward from the shaft at the intake crib. An unusually complete and extensive plant that has been installed to handle this tunnel-driving is expected to permit the work to be carried forward, day and night, practically without hindrance from the weather, or from rough water in the lake.

Aerial Tramway.—The unique feature of this plant is an aerial tramway, which is an adaptation of the type frequently used in mining districts to handle ore over considerable distances. This aerial tramway has a total length of 8,000 ft., extending from a head house over the permanent shaft on shore to a crib and head house erected at the top of the temporary construction shaft in the lake. It is carried at an average height of 35 ft. above the water by 24 four-leg steel towers, spaced approximately 300 ft. apart. This tramway will entirely preclude any necessity for tugs and scows that would be required to handle the materials excavated from tunnel, to transport men between the shore and the shaft, and to deliver supplies to the latter. The advantage to be gained by overcoming in this manner any dependence on floating equipment can scarcely be appreciated without a knowledge of the weather conditions in the locality and of the rough water which prevails in the lake along this shore during a large part of the year. Around the south end of Lake Michigan high winds are frequent at all seasons, even during fair weather, and in the winter these high winds often continue for several days, while in the summer local storms contribute an added danger. These atmospheric conditions, coupled with the comparatively shallow depth of the lake over the tunnel, cause much rough water, which renders impossible the operation of scows and tugs for considerable periods at a time. In fact, during at least five months of the year practically no reliance could be placed on floating equipment for the service required. At the same time, a very large saving in time, labor and power will be made possible by the operation of the tramway, as compared with the operation of tugs and scows, between the intermediate shaft and the shore. Furthermore, all of the limestone to be removed from the tunnel headings driven from the foot of the intermediate shaft can be saved, and after being crushed is worth $1 to $1.10 on the cars, whereas if an attempt was made to handle this rock from the intermediate crib on scows the rock could scarcely be unloaded at the shore at a reasonable cost, and would more economically be towed out and wasted in the lake. Although these are the chief advantages to be gained in operating the tramway, various others of considerable importance are presented, which in the aggregate render a successfully operated tramway a most economical installation.



Profile of Lake Section of Southwest Lake and Land Tunnel.

An elevation of one of the towers on which the tramway is carried is shown in an accompanying illustration, the towers all being the same. The controlling factors of the design of these towers were the rigidity and stiffness necessary to resist the force of the high wind and rough water to which the whole tramway will be subjected in the open lake. In providing for these conditions in the construction of the towers, a large factor of safety over the maximum load of 8,000 lb. that may be brought on each tower by the tramway is obtained.

Each tower has an extreme height of 30 ft. 5 in. and is 12 ft. square at the base, its four legs converging from the base to the top, as the corners of a pyramid, the tower being 1 ft. x 2 ft. 1 in. in plan at the top. Each leg of the tower consists of a 3½x3½x⅜-in. angle, the four legs of the tower being quite completely cross and sway-braced, as shown in the accompanying illustration, to obtain the necessary rigidity and stiffness.

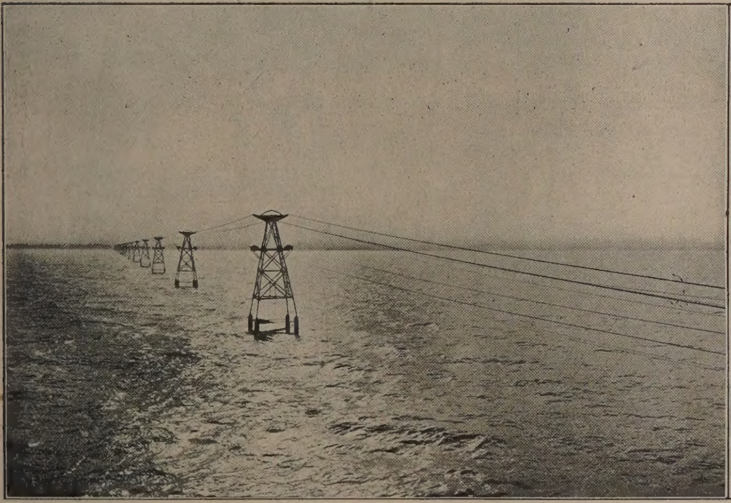
Each leg of the tower is carried by an extra-heavy built-up steel pile, designed specially for this purpose. The tops of all of these piles are at the same elevation, 5 ft. above Chicago datum, which is about 1 ft. below the mean water level of the lake. The depth of water in the latter increases gradually from about 6 ft. close to the shore to 33 ft. at the outer end of the tramway, the average depth in this distance being 25 ft. The piles carrying the towers were built in lengths varying from 22 to 49 ft. and were driven by a floating pile-driver outfit practically to refusal in the hard blue clay which forms the bed of the lake over the whole site of the tramway, except near the shore, where an overlying stratum of sand and gravel occurs. The cross-section of each pile forms two sides of a hollow square, 12⅞ in. on a side. Two general sections of the piles were built, one for those from 22 to 43 ft. in length, and the other for piles up to the maximum length of 49 ft. Both sections are unusually heavy and are arranged to produce an exceptionally rigid column. The four piles of each tower are fastened together at the top by a pair of diagonal tie rods, and at the water level by two pairs of 2-in. rods, also placed as diagonals. A frame of 12-in. channels, 11 ft. 11 in. square, is also placed horizontally inside the four piles carrying each tower, 6 ft. below the surface, and is lashed to each of the four piles.

The tendency of the towers to tip, due to unbalanced loads on the tramway or other cause, is prevented by six inclined braces to each set of four piles for a tower. These braces are all attached at the water level, and each extend down to an anchorage set in the bed of the lake. Four of them are each at one end of the two diagonals of the square formed by four piles. These four inclined braces on the diagonal lines are 6x6x¾-in. angles, in lengths varying from 14 to 36 ft., depending on the depth of water at the different towers. Each of these angles is lashed to the pile for which it is a brace by a chain rove through holes punched in the angle and in two ½x6-in. reinforcing plates riveted to the upper end of the brace. Each of these four braces are placed at an angle, which brings its lower end 9 ft. from the base of the tower, where it is rigidly fastened to two short pieces of ½x6-in. plates, attached upright in a horizontal plane to two 6x½-in. plates, 15 in. long, which were set vertically their full length in the hard clay by a diver. This arrangement of plates at the base of each brace was provided more as a bearing for the brace to react against when a load is thrown on it than as an anchor.

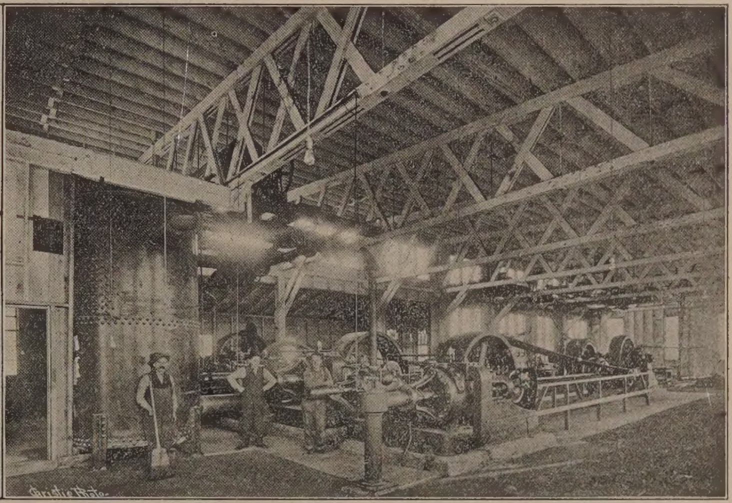
The other two inclined braces to each set of four piles carrying a tower are on the axis of the tramway, on opposite sides of the base of the tower. These braces each consist of a 9-in. 21-lb. I-beam, reinforced by two 6-in. channels, one on each side of the web. Each of these braces is attached loosely at the top through a 2-in. pin connection to a 12-in. I-beam placed horizontally between the pair of piles on the adjacent side, the connection being on the axis of the tramway. The lower end of each of these two braces to a tower is attached to a 6-ft. piece of 5-in. 6½-lb. channel, placed normal to the brace and imbedded in the bottom of the lake, to provide a reaction for the brace, the same as in the cases already cited. The lower end of each of these braces on the axis of the tramway is 12 ft. from the piles on the corresponding side of the tower, the length of the braces varying from 15 ft. to about 37 ft., depending on the depth of the water at the towers.

The construction of the towers and the arrangement of the piles on which they are mounted produce a structure for carrying the tramway cables that has already shown itself to be capable of withstanding the heavy seas and high winds which frequently prevail along the shore of the lake. No special protection against ice other than that afforded by the sub-structure of the towers as they stand has been provided, and it is not believed that any such protection will be required.

The tramway proper consists of a 1⅜-in. wire track, or carrying cable, and a ⅞-in. traction or trolleying cable on each side of the towers. Buckets are hauled out to the intermediate shaft on the carrying cable on one side of the towers, and back on the carrying cable on the other side by the traction cable. The carrying cable is of a special flat strand type, which permits the buckets to ride very easily, and has unusually good wearing properties. A saddle on each end of a 10-ft. cross arm at the top of each tower supports the carrying cable. The traction cable on each side of the towers runs normally on an 8-in. sheave wheel on the end of a second cross arm on each tower. This second cross arm is 9 ft. 2 in. below the upper cross arm, and rises in the space between the two arms when attached to a bucket.



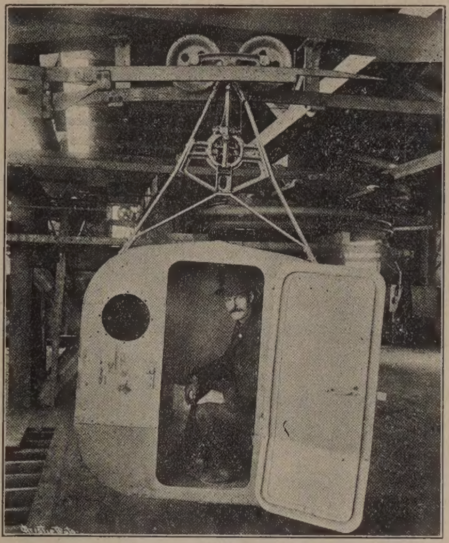
View Toward Shore From Intermediate Shaft.



Interior of Central Construction Power Plant.

The tramway buckets are built of steel, each bucket having a working capacity of 10 cu. ft., or 1,000 lb. of rock. They are each suspended on a carriage having two 16-in. grooved wheels, which run in tandem on the carrying cable. The carriage also has an automatic grip that clutches the traction cable, the latter having a normal traveling speed of 300 ft. per minute when the tramway is loaded. Under regular operating conditions about fifty of these buckets can be in service on the tramway and will be spaced 300 ft., or one tower length apart.

The rock excavated from the headings driven from the intermediate shaft will be hoisted to the surface in tunnel cars by a steam-driven 8,000-lb. freight elevator, designed specially for this service, and will be dumped from these cars into an elevated storage bin in the second story of a 76-ft. octagonal head house that has been erected on a large rock-filled timber crib, placed over the site of the shaft. The rock will be delivered from this bin, which has a capacity estimated to be equal to about 48 hr. output from the two tunnel headings, when in full operation, directly into the tramway buckets, and carried by the latter to a storage bin in a head house over the shore shaft. The terminal of the tramway at the shore end is in a second story of the head house there, the two carrying cables being connected by a loop telpherage track. As the buckets enter the building the grip on the traction cable is automatically released, so the buckets can be handled readily while on the telpherage track. The storage bin is in the first story of the head house, and the rock will be dumped from the buckets into a hopper in the floor over the bin. This dumping will probably be done by hand, although the carriages of the buckets are equipped so they may be arranged to dump automatically on reaching the hopper. The latter will be on the entrance side of the telpherage loop at the end of the tramway, and as the buckets are passed around to the opposite side of the loop, to be sent out again, the grip is automatically attached to the traction cable.



Passenger Car For Service on Tramway.

The second story of the head house over the shore shaft contains switches connecting with the telpherage terminal loop of the tramway, which switches have sufficient capacity to store all of the buckets installed. The off-shore terminal of the tramway, like the in-shore one, is also a loop telpherage track, with switch connections for storing buckets. The tramway dips down to about 25 ft. above the water at the outer end to enter the head house over the crib at the intermediate shaft.

Several enclosed cars that are provided for transporting men between the intermediate shaft and the shore are also stored on these switch connections in either head house when not in use. These cars were designed specially for the service in which they will be used and will each carry four passengers. Their bodies are oval in cross-section, being 4 ft. long, 5 ft. high and 3 ft. 3 in. wide and have a light steel frame covered with sheet iron. The entrance is through a door in one side, which closes tightly, so the only openings when the car is on the tramway are two portholes in one side of the body; a seat for two people is provided at each end of the car, so the latter makes a comfortable conveyance in any kind of weather. The carriage by which the car is suspended from the carrying cable of the tramway is very similar to the one used on the buckets, except that it is much heavier.

The 1⅜-in. carrying cable is continuous, the two ends each being attached through a take-up to a separate anchorage at the shore head house. These take-ups each consist of a pair of triple tandem blocks rove with a ¾-in. wire cable, which is wound on a drum driven by a worm-gear that can be operated by one man. These ¾-in. cables are attached to the main cable, but the latter is also attached to the anchorage as a precaution. In the head house over the intermediate shaft the carrying cable passes around a heavy frame on a 4-wheel truck, which is safely anchored, but can be moved along the axis of the tramway as tension or slack is required in the carrying cables.

The tramway is driven by a 25-h.-p. alternating current motor, which runs at 600 r.p.m., about half the capacity of this motor being required when the tramway is in operation. The motor is geared to a large drive wheel for the traction cable, the wheel being equipped with automatic grips, which reduce the wear on the cable to a minimum.

The cables, buckets and special apparatus for the tramway were furnished by the A. Leschen & Sons Co., of St. Louis, Mo., and were installed under the direction of Mr. B. C. Riblett, chief engineer of that company, by the regular forces of the contractor. The steel towers and the piles on which they stand were all fabricated in the extensive bridge and steel shops of Geo. W. Jackson, Inc., on the north branch of the Chicago River. The steel piles were also all driven and the towers erected by the contractor's regular forces.

Shafts.—The permanent shaft on shore, from which headings will be driven in both directions, will have a total depth of 145 ft., a sump, 5 ft. deep, below the invert of the tunnel, being placed at the bottom of it. Although the shaft is to have a finished idameter inside the lining of 14 ft., for construction reasons it was driven 21 ft. in diameter at the top, and will have a diameter of 16 ft. at the bottom before the lining is placed. Bed rock at the site of the shaft is at a depth of about 65 ft. The top 20 ft. of the soil overlying the rock is fine lake sand that runs like quicksand when wet and is very compact; under this sand is a 25-ft. stratum of blue clay, varying from quite soft at the top to fairly stiff at the bottom, where it grades off into a medium hard clay, below which is a stratum of hardpan and boulders directly over the rock.

The lake being only 300 ft. distant and about 10 ft. below the ground surface, the construction of a shaft of the required diameter in the running sand was a particularly hazardous undertaking, but was handled without difficulty, by using Jackson steel sheet piling. This piling consists of standard channels and I-beams, the channels being arranged in pairs, which are placed alternately with an I-beam between each two pairs. In this case standard 12-in. 20.5-lb. channels and standard 12-in. 31.5-lb. I-beams, all in 40 ft. lengths, were used. The webs of the I-beams were bent slightly to fit the curve of the shaft, but otherwise standard sheeting was employed.

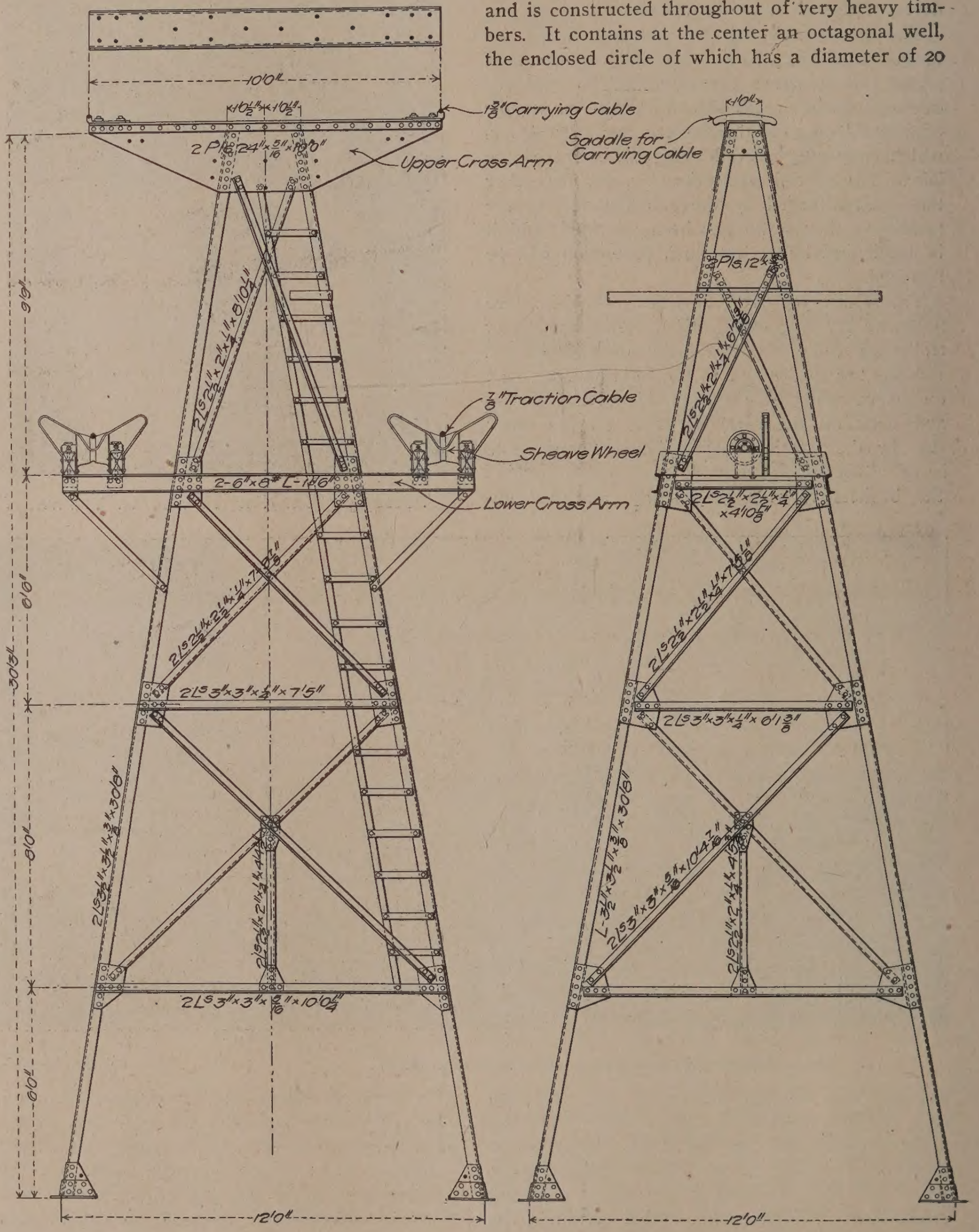
After the shaft had first been excavated to the ground-water level, at a depth of 5 ft., a template, 21 ft. in diameter and built of steel angles, was laid on the ground to serve as a guide for driving the piles. A portable turntable pile driver, having 80-ft. leads and a 5,000-lb. steam hammer, was used in sinking the piles. A stiff-leg derrick, with a 70-ft. boom, handled the piling from cars on a railroad switch that was laid along one side of the shaft, and also swung them into position for driving. The piles were first driven in a complete circle to a penetration of about 12 ft. The driver working on the outside then drove to the full depth enough piles on one side of the circle, so it could be moved inside the latter and sink the remainder from one position. The piles were all driven without any trouble, although in a few instances a water jet was used to assist the hammer. Seventy piles were required to make the complete 21-ft. ring, which has a circumference of 65.97 ft. It was contemplated that some difficulty might be experienced in closing the circle, but the last pile formed a perfect closure. The driving was done in three working days by five men, on an average, 131 lin. ft. of piling, or 1,600 sq. ft. of sheeting, being driven each day.

When the sheeting had been driven the sand, clay and so forth were excavated by hand from the area enclosed by it and were handled out in buckets by the derrick. Although the head of water on the sheeting when the excavation reached the stiff blue clay, which is practically impermeable, was at least 25 ft., only a few small leaks through the piling had occurred, and these were readily stopped by dropping clay and sawdust into the space enclosed by the pairs of channels of the piling. The excavation was carried to the bottom of the 40-ft. piling without any braces whatever, the piling having sufficient stability to maintain itself as the lining of this 21-ft. circular excavation against the heavy pressures brought against it. Below the bottom of the piling the excavation was sheeted with a steel casing, which was placed in 6-ft. sections, one telescoping inside the other, as the material was removed. The shaft was thus carried down to rock at about 65 ft. below the ground level and then left to stand for several weeks pending the installation of the balance of the construction plant. During this period a No. 2 Nye pump, working about one-sixth of the time, removed the seepage into the shaft, as the steel sheeting was practically free from leaks with the full head of water against it.

The two-story head house over this shore shaft is 46x65 ft. in plan and contains the terminal of the tramway on the top floor and a rock storage bin on the first floor, as has been stated. The rock from the tunnel headings driven from the shaft over which this house is built will be hoisted in tunnel cars by an electrially operated 8,000-lb. elevator in the shaft and dumped into the storage bin. An elctrically driven rock crusher is to be installed in the first story of the building to crush the stone for market. The crushed stone can be loaded directly into the cars on a railroad switch along one side of the head house, or the run-of-mine stone can be loaded into these cars. As more than 125,000 cu. yd. of rock will have to be removed from the tunnel and passed through this head house, the handling of the rock after it reaches the storage is alone a very large undertaking.

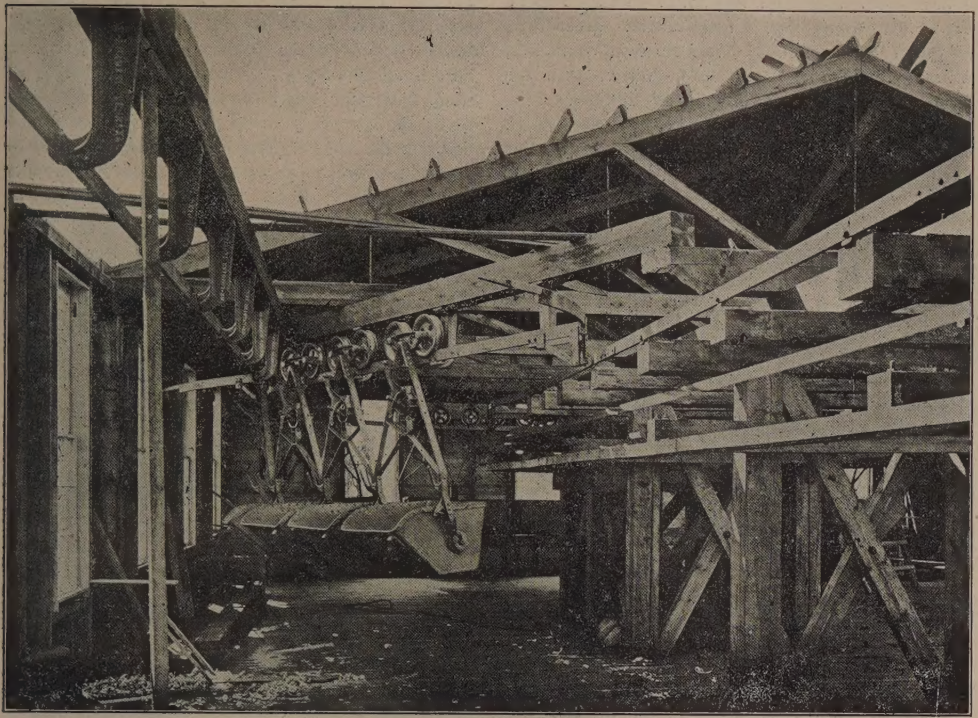
The bottom of the intermediate construction shaft in the lake is to be 137 ft. below the mean lake level, the water varying from 33 to 36 ft. in depth at this shaft, under different barometric conditions. Rock is at a depth of about 60 ft. below mean water level and is overlaid by 27 ft. of material varying from hardpan immediately over it to soft blue clay at the surface of the bed of the lakes. A heavy rock-filled octagonal timber crib, with an inclosed circle having a diameter of 76 ft., has been placed concentric with the shaft and carries the head house for the latter. This crib has a total height of 65 ft. and is constructed throughout of very heavy timbers. It contains at the center an octagonal well, the enclosed circle of which has a diameter of 20 ft., and around this well are the pockets for the rock fill. The sides and bottom of these pockets are made practically watertight to 12 ft. above the water level by 3-in. oak sheeting, thoroughly calked.

The shaft is to be encased down to the rock with Jackson steel sheet piling, which is carried up 9 ft. above the water level, making the total length of the sheeting 69 ft. The circle enclosed by the sheeting is 20 ft. in diameter to a depth of 46 ft. and 12 ft. in diameter below that depth. The large circle at the top is formed by sheeting of the same size and weight as that used in building the shore shaft, and is in 51-ft. lengths,



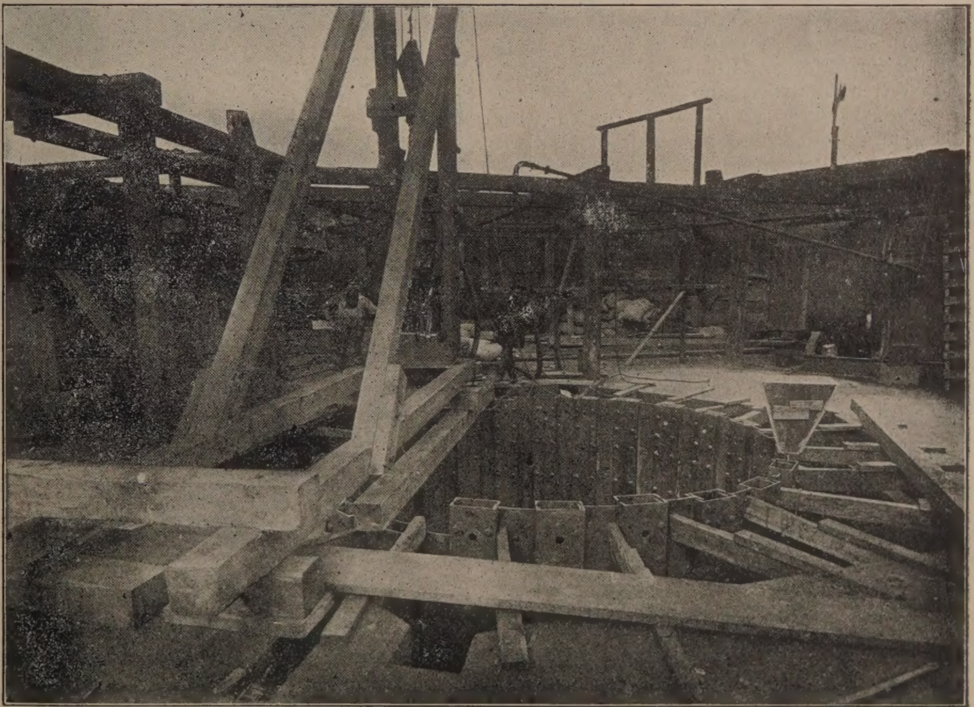
Details of Tramway Towers.

which have a penetration of 9 ft. into the clay bed of the lake. This sheeting has been successfully driven, and at the time these notes were prepared the space between it and the walls of the well of the crib were being filled with packing material, in order that the water might be pumped out of the area enclosed by the sheeting, and the excavation be carried down sufficiently to permit a second set of sheeting to be driven for the smaller circle. The top of this second set of sheeting, which consists of 5-in. 6½-lb. channels and 9-in. 21-lb. I-beams, is to overlap the bottom of the upper set about 2 ft., thus forming, together with the material between the two, a joint that should be perfectly safe, as it is 7 ft. below the surface of the bed of the lake.



Tramway Buckets on Telpherage Switches in Head House Over Shore Shaft.

The crib was built in a slip in the Calumet River at South Chicago, about three miles from the site. After it had been completed it was loaded with rock until it drew about 20 ft. of water, and on a day when quiet water was practically assured it was towed to place by three tugs in about three hours. It was then guyed in position and the rock filling required to sink and anchor it was placed. About 500 cords of stone were placed in the ballast pockets by two derrick scows, which completed this work in two days, although the crib was safely anchored 11 hours after it reached the site. A foundation of piles had been driven previously in the bed of the lake at the site and were sawed off at the surface of the clay, and the crib settled into position on this foundation without a mishap.



Steel Sheeting Driven to Form 20-Foot Circular Shaft at Intermediate Crib.

Central Power Plant.—A most complete central power plant, including a machine shop and a blacksmith shop, has been erected adjacent to the shore shaft, to supply power for operations in the tunnel and at the two shaft head houses, and for such other purposes as are necessary. The plant is in a 50x165-ft. frame building of unusually substantial construction for such purposes. A 25x50-ft. blacksmith shop is placed in the rear. In one corner of the front end of the main building is a row of four separate 12x21.5-ft. rooms, which provide a general office, an office for the contractor's engineers, an office for the city engineers and a bath and toilet room. The remainder of the building is one large room, which is free from columns, the roof being carried by light wooden trusses with a clear span of 50 ft.

These trusses are of quite simple and satisfactory construction. They are built entirely of 2x8-in. and 2x10-in. plank and 1-in. iron rods, without requiring any framing and very little cutting, all of the latter having been done with a hand saw. One truss was laid out so a complete set of pieces could be cut for it, then these pieces were used as patterns, from which the material could be cut for the whole series of trusses. The trusses each contain about 20 ft., board measure, of lumber to the linear foot and weigh approximately 3,500 lb. They were therefore easily erected with a light gin pole equipped with hand blocks.

All of the equipment in the power plant is driven by electric motors operating on power supplied from the commercial circuits of the Commonwealth Edison Co. This power is received as 3-phase 4,400-volt alternating current and is stepped down to 440 volts for use in the plant by a bank of transformers along one side of the building. A 250-kw. direct-current generator, direct connected to an alternating-current motor, is also installed to furnish direct current at 250 volts for operating the elevator in the shore shaft, electric locomotives in the tunnel headings, and so forth.

Four motor-driven Ingersoll-Rand air compressors, with a combined capacity of approximately 4,000 cu. ft. per minute, have been installed in the power house to furnish air to operate rock drills at the face of the excavation in the tunnel headings. These compressors are all compound duplex machines. Two of them, with 14¼-in. and 22¼-in by 14-in. cylinders, each have a rated capacity of 841 cu. ft. of free air per minute, when operating against 80-lb. pressure, and are each belt-driven by a 150-h. p. General Electric motor. The other two, with 16¼-in. and 25¼-in. by 16-in. cylinders, each have a rated capacity of 1,205 cu. ft. of free air per minute, when operating against 80-lb. pressure, and are each belt-driven by a 200-h. p. General Electric motor. These motors are each equipped with a starting device within the frame of the machine.

The four compressors all deliver into either of two 6 x 12-ft. upright receivers in the building. A 10-in. pipe header is extended from these receivers to the adjacent shore shaft, where a 9-in. line is taken off, and a 7-in. line, 8,000 ft. long, is continued out to the intermediate shaft in the lake. The 7-in. line is flanged spirally-riveted steel pipe from the shore line to the intermediate shaft and is placed on the bottom of the lake, with flexible joints to provide for variations in grade. This pipe is designed for a working pressure of 200 lb. per square inch and weighs about 9 lb. to the linear foot.

The entire compressor equipment has been placed in one central power plant on shore and a pipe line carried in the intermediate shaft, rather than to transmit electrical power to that shaft to drive a compressor there, for two principal reasons. First, no space was available in the head-house over that shaft. This head-house and the crib on which it stands are very large and expensive, but the provision of the additional space required for a compressor would have involved an increase in the cost of building a larger crib which would not have been in keeping with the advantage to be gained. On the other hand, the operation of two separate compressor plants would have occasioned double the expense for attendance that is required by a single central one. Furthermore, advantages for ventilating the tunnel headings which are afforded by the one central installation could not be obtained with two separate plants.

It is contemplated that 24 to 30 air drills will be worked in the two headings to be driven from each shaft, and on this basis the 4,000 cu. ft. per minute of air capacity that has been provided might appear to be more than is necessary. It was held, however, that the provision of more power than is generally considered to be required would preclude any possibility of shut-downs of the extensive plant due to one compressor being out of service. Another great advantage of the large amount of available air power is the ability to clear the gases from the headings after a blast. Arrangements will be made to deliver the full output of all four compressors at the face of the excavation in a heading directly following a blast. This will undoubtedly greatly reduce the delays which are occasioned under ordinary circumstances by waiting for the gases to disperse, and will also clear the atmosphere so thoroughly that the laborers at the face can deliver more efficient results when they return to work again.

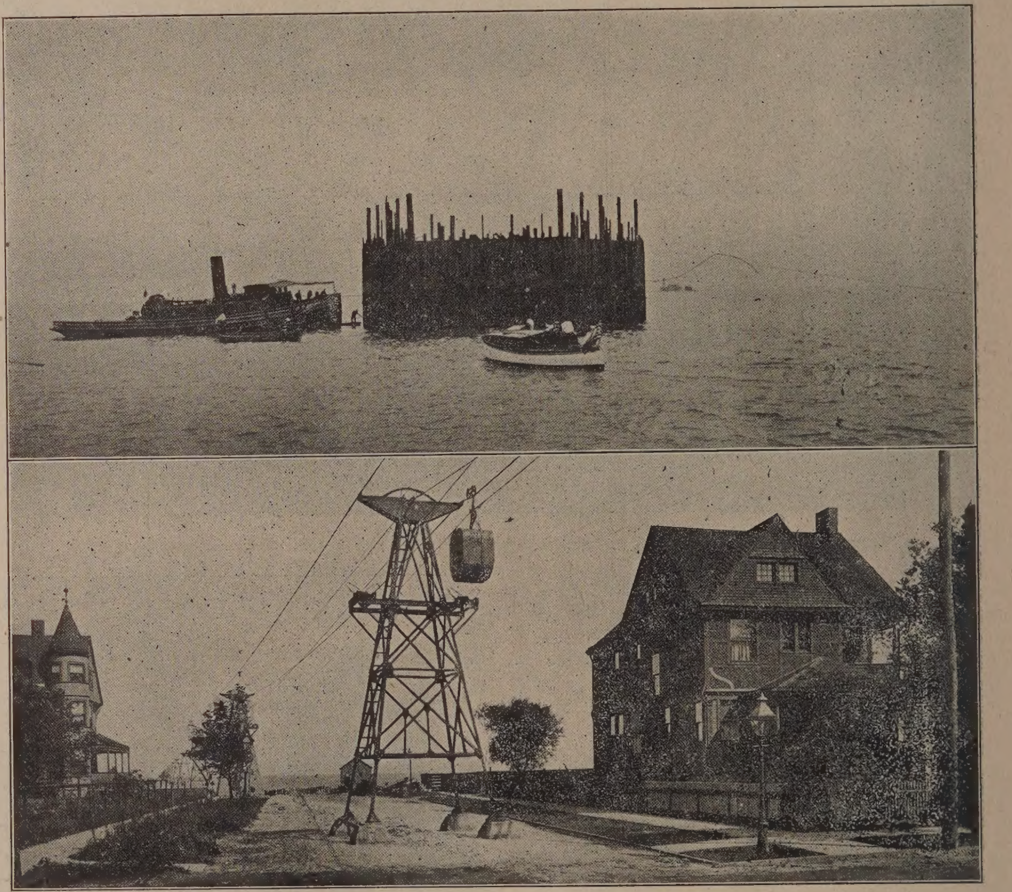
Direct-current electrical power for operating the locomotives to be used in the headings driven from the intermediate shaft and for pumps in the latter is transmitted on two bare copper wires carried on insulators on the center line of the top cross arms on the tramway towers. The elevator for this shaft is arranged to be driven by a steam engine, in order that the men in the headings may be hoisted to the surface whether current is available or not. Alternating current for lights in the head house of the intermediate shaft, in the tunnel headings driven from the latter and for a light at each of the tramway towers is carried from the central power plant by a pair of insulated wires on the top cross arm of the towers. A regular nautical signal lamp is also maintained on each tower as an added precaution. A very powerful searchlight, mounted at such a position slightly to one side of the inshore end of the tramway that it can be thrown the full length of the latter, greatly assists in operating the tramway at night, as well as affording an additional safeguard to shipping.

A quite complete machine shop has been installed in the rear end of the power plant building. This shop includes a drill, a 12-in. 8-ft. lathe, a 22-in. planer, a radial drill with a 12-ft. arm, a pipe threader, a steel saw and a grindstone. All of this equipment is driven from line shafts by a 25-h.-p. motor carried on a bracket suspended from a roof truss. A smaller motor would have sufficient capacity to drive these various machines, but the larger one was installed in order to have enough power to start the motor-generator set. The equipment in this machine shop, and in the blacksmith shop, which contains two 6-ft. forges, a small air-driven trip hammer, an emery wheel and a radial drill, permits practically all repairs to the construction plant to be made at the work. Repairs that cannot be handled by this equipment will be made in the bridge and steel works of Geo. W. Jackson, Inc., so all dependence on outside sources for such work is avoided.

The Southwest Land and Water Tunnel is being driven under the supervision of Mr. John Ericson, city engineer of Chicago. Mr. G. F. Samuels is engineer in charge for the city. Mr. Geo. W. Jackson, president and chief engineer of Geo. W. Jackson, Inc., has personally directed the installation of the construction plant and will supervise the operation of it.

Harbor Work at Huron, Ohio.

The United States Government is at present making improvements in the harbor of Huron, Ohio, a small city on the south shore on Lake Erie near Sandusky. The Huron River was originally obstructed by a sand-bar at its mouth, which closed it to navigation, and in 1826 the first project for its removal was adopted. This provided for two parallel timber jetties 90 ft. apart, extending into the lake from the river bank. These jetties were lengthened and repaired from time to time, and the channels finally deepened by dredging to 16 ft. Altogether, up to June 30, 1905, the United States Government had expended $269,908.95 on the project, and in addition considerable dredging had been done by local authorities.



Anchoring the Construction Crib; and Passenger Car at Land Tower of Tramway.

The existing project was authorized by the River and Harbor Act of March 3, 1905, and provides for a channel, with a depth of 20 ft. It utilizes all of the west jetty which was serviceable, extending it 240 ft. and terminating it at a pierhead 50 ft. square. A similar pierhead was constructed 300 ft. easterly from the extremity of the west jetty and is now being connected to the shore by a rubble mound breakwater, which extends from the pierhead to a point 1,200 ft. east of the present east jetty. Upon the completion of the work the latter is to be removed. The west jetty has a length of 1,741 ft., and the breakwater when completed will have a length of 1,756 ft.

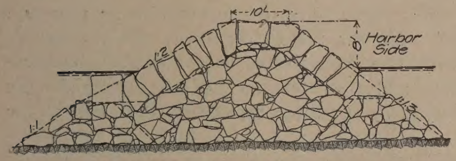
The west jetty consists of 1,109 ft. of timber cribs, 582 ft. of timber crib with concrete superstructure and 50 ft. for the pierhead. The old timber cribs were used as far as possible in the improvement work. They were built at different times and differed materially in details of construction, varying in width from 16 to 24 ft. The bottom of the lake at this point is a stiff clay, and the cribs were sunk in trenches excavated in this material, without the usual rip-rap foundations. The cribs have settled considerably and lost their true alignment.

Where the old cribs were capped with the new concrete superstructure the cribs were cut down to 3 ft. below mean lake level, and a line of concrete blocks was set on both the river and harbor sides of the jetty. These blocks were aproximately 4 by 4 ft. and of sufficient length to span from one cross timber of the crib to the next, about 8 or 9 ft. To give a proper alignment to the superstructure it was frequently necessary to give these blocks irregular forms instead of the cross sections originally designed. The space between the concrete blocks was filled in with rip-rap and surmounted with concrete placed in mass to a height of 6 ft. above mean lake level. The pierhead of the west pier was given a height of 14 ft. above datum, to provide a foundation for a lighthouse.

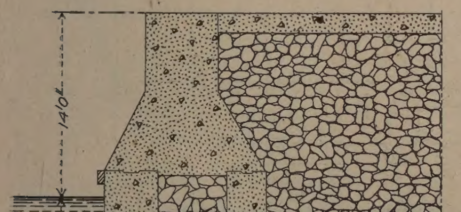
The breakwater, or west jetty, consists of a rubble mound of quarry-run stones covered with large placed stones. On the harbor side the slope is one on one from the bottom to 12 ft. below mean lake level, and one on two to the top of the structure, which is 8 ft. above datum. The width of the top is 10 ft.

The average weight of the quarry-run stones of which the jetty is built is 1½ tons, running all the way from 200 lb. to 5 tons in individual pieces. The specifications required that no stones should have a thickness of less than 1-3 its greatest dimension. The placed stone is aproximately rectangular in shape, with no angle sharper than 60 deg., or more obtuse than 120 deg., weighing from 4 to 10 tons. The specifications require it to be set close with a derrick on the best and largest bed, adjacent stones not to be farther apart than 18 in. The stones are set to break joints and tie the work together as far as possible, and on the slopes none vary more than 12 in. from the adopted outline. The lowest outside row of the placed stones on each side is set flat, with the tops of the stones as near as possible at mean lake level, while the remainder of the covering stone is placed edgewise.

In constructing the breakwater the contractor built a private storage yard near the shore end of the jetty and adjacent to the tracks of the Wheeling & Lake Erie R. R., and a track was laid from this storage yard out onto the jetty, being lengthened as the work progressed. An Interstate Engineering Co. 8-wheel locomotive crane weighing 65 tons and having an 80-ft. boom handles all of the stones from flat cars run out on the jetty behind it. For a time this crane also switched the cars back and forth from the yard to the jetty, but as the breakwater reached a length of 700 ft. a small locomotive was placed in service, to prevent the large loss of time due to switching by the crane. In extending the breakwater the crane throws the quarry-run stone into the water in advance of the work, until the rock is built up to about 1 ft. above the water for about 30 ft., sufficient to lay one section of track. The top of this new section is leveled off with small rip-rap, and upon it are laid track stringers carrying closely spaced ties. The top of rail is aproximately 2½ ft. above the level of the lake.



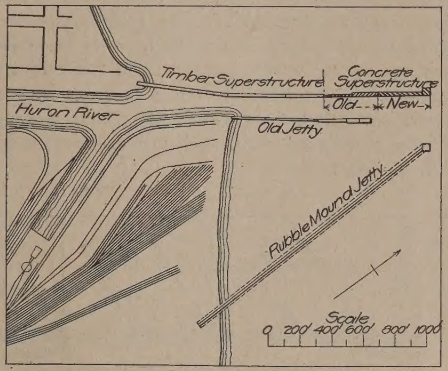
Rubble Breakwater at Huron.



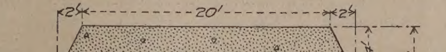
Half Section of Pierhead at Huron.

About eight days are required to fill one of these 30-ft. advance sections of the breakwater. When the track is in place on the new section the placed stones are set on each side of the jetty, leaving the track clear. This method is being followed on the entire length of the structure, and after it is joined to the pierhead the crane will work backwards, setting the placed stone over the portion now given up to the roadbed. Some of the placed stones have weighed as high as 14 tons, while a great many have been used which weigh 10 tons, the average being about 5. The average day's work for 8 hr. is about 200 tons of quarry-run and placed stone combined, and the maximum tonnage for one day, consisting entirely of quarry-run, is 454 tons. The estimated weight of stone in the entire breakwater is 63,500 tons. The usual force required in filling the breakwater consists of a superintendent, a foreman, an engineer and a fireman on the locomotive crane, the locomotive crew and three laborers. When the riprap is being placed and the track laid an additional force of laborers is required. The contractor for the work is Hunkin Bros. Construction Co., of Cleveland. Most of the stone is limestone from Bellevue, Ohio, 26 miles from Huron, though a small quantity of sandstone has been obtained from North Amherst, Ohio.

While this work has been in progress the Wheeling & Lake Erie R. R. have constructed two basins near the mouth of the Huron River and propose to construct a third one opening into the harbor behind the breakwater. The basins have a depth of 21 ft. and are enclosed by timber retaining walls. The material excavated from the larger basin was used to fill a marsh forming part of the company's property north of the tracks of the Lake Shore & Michigan Southern Ry.



Plan of Huron Harbor.



Concrete-Topped Crib at Huron.

The work is being carried on under the direction of Lieutenant Colonel C. McD. Townsend, Corps of Engineers, U. S. A.

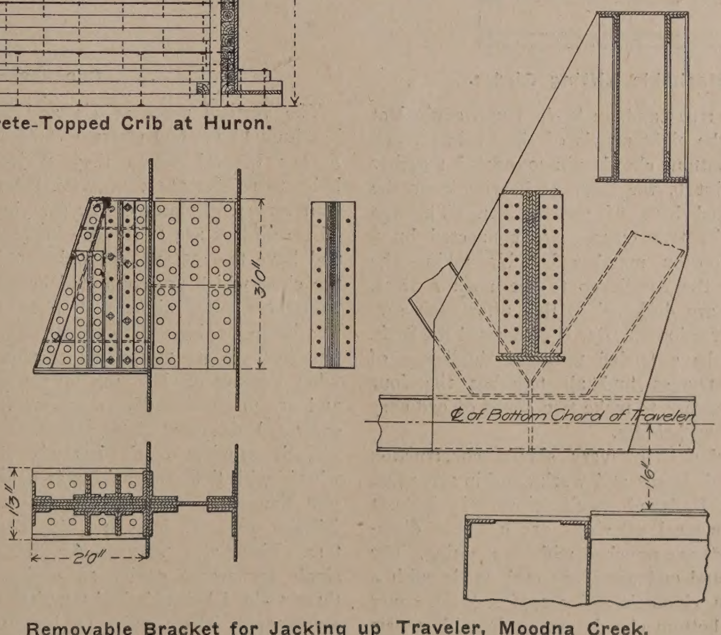
THE ELECTRIC LOCOMOTIVES being used in the Simplon Tunnel are troubled with excessive condensation, affecting the insulation, due to the difference in temperature in the tunnel and outside.

The Erection of the Moodna Creek Viaduct.

The Erie & Jersey R. R. viaduct across Moodna Creek, New York, is 3,200 ft. long and about 182 ft. high, and is composed of alternating 40 and 80-ft. plate girder spans supported on steel towers as described in The Engineering Record of July 6, 1907. As now under construction, it contains about 4,000 tons of steel and will carry a single track, but it is designed for future conversion to a double-track structure by the addition of two more lines of plate girders and column reinforcements amounting to about 1,750 tons of additional steel work.

The longitudinal girders 5½ ft. deep and 9 ft. deep are of ordinary construction, web-connected at the ends to double transverse plate girders 10 ft. deep which are riveted across both faces of the battered tower columns. The end sections of the webs are shop-riveted to the columns and have field riveted cover splice plates, field riveted to the ends of the 13-ft. long center section. The maximum towers are 5 stories high with the panels X-braced in both faces but have horizontal struts at panel points only in the transverse plane. In the tallest tower one column in each bent has a roller bearing on the pier masonry. Expansion ends are provided for the 80 ft. girders about 240 ft. apart where they have a sliding bearing in a pocket attached to the web of the transverse girder, all other girder bearings are fixed.

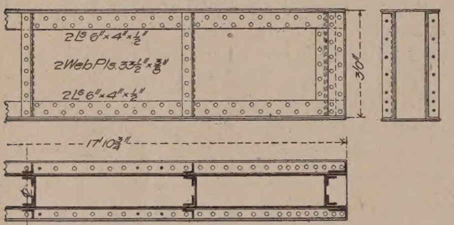
The viaduct was erected by a steel traveler designed also for use in the construction of other extension works now in progresss for the Erie R. R. system. The overhead traveler is a simple rectangular framework 200 ft. long, 30 ft. high and 19½ ft. wide on centers, which weighs about 100 tons. It is designed as a cantilever with an 80-ft. overhang and booms projecting from its extremities with sufficient length and capacity to handle tower members 120 ft., or 2 spans distant from the end of the completed structure. It is of special and rather peculiar construction, differing materially from ordinary travelers in the method by which it is supported from and advanced on the finished structure, in the provision made for handling through it unloading and lowering the members of the viaduct and in the plans for utilizing it for other purposes and realizing a heavy salvage after its work in erecting these viaducts is finished.



Removable Bracket for Jacking up Traveler, Moodna Creek.

It consists essentially of a riveted Pratt truss span with riveted members throughout and with lateral bracing only in the planes of the top chord. There is no transverse connection between the bottom chords nor between the members of the trusses except what is afforded by the sway-brace frames, 12 ft. deep, and temporary wooden studs replaced and removed as necessary during erection. A clearance generally 18 ft. wide and 18 ft. high is thus provided through the traveler to allow for car service and the handling of material through it from end to end. This clearance is reduced to 15 ft. vertical by the overhead hoisting engine platform, 43 ft. long, built between the trusses at the rear end of the cantilever. It is not, however, diminished by the duplex-geared girder crane of 15 tons capacity and 16½ ft. span which runs on tracks made with I-beams 100 ft. long to the outer end of the traveler.

When in service the traveler is supported at panel points L0 and L6 at the rear extremity and on the last completed bent of permanent structure with pin bearings in ordinary shoes and pedestals, the latter being seated on the top flanges of the transverse girders of the viaduct towers. At each bearing the traveler is anchored by vertical bolts with nuts at both ends bearing against the bottom chords of the traveler and the bottom flanges of the transverse girders in the viaduct. When the traveler is advanced, temporary transverse plate girders are connected to vertical posts 1 and 6 a little above their lower ends and the traveler is lifted by jacking up under them and then lowering it to supports on special trucks that travel on the regular permanent track of the viaduct.



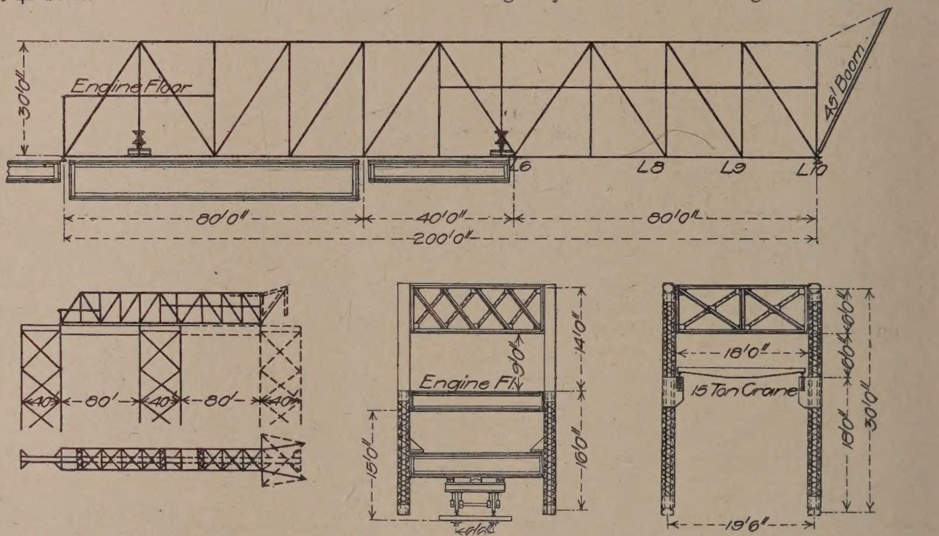
Detachable Lifting Girder.

Each traveler truss consists virtually of a complete 120-ft. truss and an 80-ft. truss, equivalent to four of the eight panels of the viaduct truss, with their bottom chords pin-connected together at panel point 6, the forward bearing over the last completed bent of the viaduct. The top chords of the two trusses are connected by a horizontal tension member U5 U7 taking the stress from the cantilever to the anchor arms. The trusses are designed so that after their service in the erection traveler is completed the 80-ft. trusses can be extended to make duplicates of the 120-ft. trusses and all together the four trusses will suffice to make two spans of ordinary 120-ft. highway bridges.

The traveler is of very simple construction with standard details and workmanship according to the Erie Railroad specifications. It is built with medium steel, all rivets are ¾-in. in diameter and holes are punched without reaming. The top chords and end posts are each made with a pair of 10-in. channels and a 17½ x ¼-in. cover plate. The bottom chords are made with a pair of 12-in. channels, latticed on both flanges, and the vertical and diagonal members are made with pairs of channels latticed and bolted at both ends between jaw plates shop riveted to the webs of the top and bottom chords. The transverse sway-brace struts are like lattice girders 6½ and 12½ ft. deep, the former being completely shop riveted and the latter having their members shipped loose and bolted together and connected in the field. The top lateral diagonals are single angles, one of which is continuous across the panel and the other is cut to clear it at intersection and spliced across and connected to it by a bolted flange cover plate.

Each main bearing is made with a 3½-in. pin engaging the double webs of a riveted shoe bolted to the bottom chord of the truss and having three alternating bearings in a cast-iron shoe with horizontal transverse guide strips engaging the edges of the top flange of the transverse header girder of the finished viaduct over the center of the viaduct column. Three bearings are provided for each truss, one at the rear end, one at the inner end of the cantilever and one at the outer end of the cantilever, to engage the advance bent of the tower as soon as it is erected.

At L1 and L6 the bottom chords of the trusses are spliced with web cover plates which project far beyond the top flanges to form jaws providing for the connections of the vertical and diagonal posts, and also receiving, on their inner faces, very heavy brackets to take the reactions of the hydraulic jacks used to lift the traveler from its bearings to the truck and from the truck to its bearings. These brackets are 3 ft. deep with a lower horizontal flange 2 ft. long and a very heavily reinforced web, and are each attached with 42 bolts.



Cantilever Viaduct Traveler Used at Moodna Creek.

The vertical posts at U1 and L1 have wide longitudinal vertical plates riveted to their inner flanges beyond which they project with open holes to receive the connection bolts through the transverse end plates of the carrying girders G1. These girders are 17 ft. 10¾ in. long, out to out, and have two 35½x⅜-in. webs 10¼ in. apart in the clear which are connected by five equidistant transverse diaphragms and have four 6x4x½-in. flange angles. The three intermediate diaphragms are set at the points where the girder takes bearing on blocking on the moving truck, and are proportioned to reinforce it for the concentrated shears at these places.

Each moving truck has six double flange wheels with their journal boxes bolted to the bottom flanges of two pairs of 15-in. longitudinal I-beam sills 7 ft. long and 6½ ft. apart on centers. These sills carry across their top flanges a single transverse girder 10 ft. long made with three 15-in. I-beams bolted together with cast-iron separators. Three pairs of longitudinal yellow pine cushion blocks on the top flanges of this girder give bearing against the transverse carrying girders G1. The vertical posts at the outer extremities of the cantilever trusses serve as masts for 45-ft. wooden derrick booms with fittings made at Erie Railroad machine shop. The total weight of the traveler is about 200,000 lb., and it is proportioned to carry a concentrated load of 30,000 lb. at the extremity of each cantilever truss.

After completing two panels of the viaduct the traveler is advanced until panel points L6 are centered over the last transverse tower bent completed. Hydraulic jacks are then set on the tops of the transverse girders with their upper ends engaging the lower flanges of the lifting brackets at panel points L0 and L1 and are operated until the traveler is lifted clear of the cushions on the trucks. The trucks are then withdrawn and the jacks are slacked off to lower the traveler to bearing on its shoes and pedestals and it is anchored to the viaduct by sixteen 1-in. vertical rods 6½ ft. long, engaging the bottom chord as already described. The two bearing girders G1 are then detached and placed with the trucks at one side, out of the way. The viaduct members are then brought inside the traveler by cars on the material tracks which deliver them to the girder crane, and the latter carries the material for the respective towers out to position and lowers it, to be swung into place by auxiliary tackles, and then while the bent is securely guyed brings out the 80-ft. girders and seats them on it.

After these are connected the bearing and anchorage for the extremity of the traveler at points L10 are adjusted on top of the transverse bents and the remainder of the materials are brought by the tower and the girder crane to the derrick booms on the end of the traveler, which completes the erection of the tower and sets the 40-ft. girders on it. The girders G1 are lowered and reconnected in their former positions, the trucks are brought out and placed under them and the hydraulic jacks are set under the lifting brackets again and raise the traveler clear of the trucks to which it is lowered, the jacks released and the traveler advanced 120 ft. as before and so on. The movement of the traveler is thus accomplished easily and quickly on the material track, and the bearings on the center lines of the trusses over the tops of the tower columns utilize the full width of the viaduct notwithstanding that the latter is only equipped with a single pair of girders close together for a single track.

The Erie Railroad construction department is under Mr. J. M. Graham, vice-president, and Mr. Francis Lee Stuart, chief engineer, under whose direction the viaduct was designed by Mr. Mason R. Strong, engineer of bridges and buildings, with the assistance of Mr. F. A. Howard, assistant engineer of bridges and buildings. The erection has been done by the Bridge and Building Department, under the charge of Mr. W. H. Wilkinson, inspector of bridges. The steel work was fabricated by the McClintic-Marshall Construction Company.

Fuel Oil on Locomotives is largely used in Mexico, where about 4,000 bbl. are now consumed daily, it is stated, on the Mexican Central Ry. alone. More locomotives are now being fitted with oil burners as a result of the satisfactory experience in the past. The oil costs about $1.10 per barrel, giving a material saving over coal.

A Favorable Report on the Calumet Drainage Canal.

On Oct. 19 Mr. Rudolph Hering submitted a report to the Trustees of the Chicago Sanitary District which will unquestionably be the leading argument they will use in their endeavor to secure permission from the Federal authorities to turn 4,000 cu. ft. of lake water per second into the drainage canal in addition to the 10,000 cu. ft. per second which the International Waterways Commission has approved. It will be recalled that Messrs. Hering & Fuller were retained by the International Waterways Commission to report on certain features of sewage disposal in the Calumet District lying south of Chicago, and that their report was in favor of septic tanks and sprinkling filters. As Mr. Hering was the engineer who designed the main features of the Chicago drainage canal, this report has been regarded by a good many people as indicating a change of opinion on his part concerning the methods of sewage disposal advisable for the district about the lower end of Lake Michigan. In order to counteract any such view, in all probability, the Trustees of the Sanitary District retained him to report on the most desirable method of disposing of the sewage of the so-called Calumet sub-division of the Sanitary District without causing a nuisance or any pollution of the lake water, irrespective of previous recommendations or legal restrictions. He was requested by the Trustees to take a comprehensive view of the problem, so that any recommendation he made would be in line with what appears to him to be the proper solution of sewage disposal problems in the distant future. He was also requested to furnish estimates of cost and any attending benefits that would be associated with whatever method he recommended. The conclusions in his report are as follows:

The Calumet Subdivision is the term used for that part of the Sanitary District lying south of 87th street, because for the territory north of that street provision for sewerage already exists or has been planned. The Calumet River passes through its southern part and resembles both in ordinary and flood discharges the Chicago River before its flow was reversed. There is also a low divide a few miles to the west, beyond which the drainage flows into the Desplaines River at Sag, and thence to the Mississippi River. Much of the territory is already provided with sewers, which take both sewage and rain water, except a small area at Pullman, where these waters are separated.

The lowness of most of the area makes it necessary for much of the sewage and rain water to be pumped. At 95th street, near the mouth of the river, there is a pumping station for this purpose. Under flood conditions sewage enters the lake, which in the future, and perhaps already, must endanger the wholesomeness of the water at the Hyde Park intake of the Chicago waterworks.

There are two methods available for properly disposing of the sewage in the Calumet region, so as to prevent the pollution of the water supply of the city and prevent any nuisance in the river or on land. One of these methods is purification by means of septic tanks and sprinkling filters, the other is by repeating the method now used in Chicago and building a canal from the Calumet River across the low divide to join the present sanitary canal at Sag, and by reversing the flow of the Calumet River to carry in it sufficient water to dilute the sewage properly. Whenever this flow is less than required, the deficiency is supplied from the lake; whenever it is greater, the excess flow goes to the lake. To guard against the sewage being carried into the lake at such times, it is necessary to build intercepting sewers to discharge it into the canal and not into the river.

At the request of the International Waterways Commission, the various "available methods of disposing of the sewage of the Calumet area, other than by dilution," were studied and sprinkling filters recommended as "being the cheapest, both in cost of construction and operation, and accomplishing an adequate degree of purification." Under the instructions of the Sanitary District Trustees, Mr. Hering has now compared this method with the dilution of the sewage in the Calumet-Sag canal.

The dilution method was studied by experience gained during its application in Chicago, since the sanitary canal has been opened. The canal was originally designed to carry 10,000 cu. ft. per second, sufficient to dilute the sewage of 3,000,000 persons. Above Summit provision for this population is being made; below Summit the canal is now capable of carrying 14,000 cu. ft. per second, but between Summit and Sag it is proposed to carry only 10,000 cu. ft. per second, and at Sag to receive 4,000 cu. ft. per second through the proposed sanitary canal from the Little Calumet River. This project will protect the lake water from receiving any sewage, Mr. Hering states. It will permit controlling the proper flow in the canal at all times and dilute the sewage of 1,200,000 persons in the same manner as the main canal now built.

In order to compare the two projects, it is necessary to know their true values, which must be based upon their cost and collateral advantages. A most important item for those who pay the taxes is the cost. This is obtained from a balance between expenses and receipts. The expenses should be stated as the total annual cost, made up of operating expenses and fixed charges for interest and other items. The receipts should be given as the returns from the sale of products. There is no money returned from the sprinkling filters, as their product has no value. But there is a return from the dilution project, because the flow of 4,000 cu. ft. per second can drop 66 ft. and develop 22,500 efficient horse power. This earning power produced by the money spent in building the canal to supply the water is an asset as much as if it had been built especially for water power purposes. It is an asset as much as the products yielded from mineral land originally bought from the government and as much as rent secured from a building.

Mr. Hering gives the accompanying table, showing the net annual cost of the two methods of disposal for a population of 300,000 in the Calumet region, and a future population of 1,200,000; these figures are based upon the use of sprinkling filters and upon the Calumet-Sag canal, first, for its actual cost, second, its cost with a return for power at Lockport, and third, with a return for power at both Lockport and Joliet. This table indicates that for an early population of 300,000, the canal project would cost annually about one-third as much as filters, and for a population of 1,200,000 about one-quarter as much, not considering any value which the canal may have for the purpose of navigation. The table further shows that when the population is 1,200,000, the presumable annual cost of the canal project, even without any returns from the sale of power, would be $136,600 less than that of sprinkling filters. Even a material variation in the cost would not alter the general conclusion that the canal is the cheaper project, Mr. Hering states.

The cost comparison alone would decide which project is the more desirable one for the citizens of Chicago, if there were not objections apparently more or less serious that have been raised against the Calumet-Sag project. These objections can be satisfactorily answered, Mr. Hering reports. The most important of them are stated below.

ANNUAL COST, INCLUDING OPERATING AND FIXED CHARGES.

Installation for a Population of	Sprinkling Filters.	Calumet—Sag Canal. Cost of Canal Alone.	With power at Lockport.	With Power at Lockport and Joliet.
300,000	$360,240	$656,900	$384,100	$128,800
1,200,000	900,300	763,700	490,000	235,600

A question has arisen as to whether it would not be more economical to utilize the main canal and its feeders to their full capacity for the central district of the Chicago metropolis through which it runs, and to erect sewage treatment works for all the more distant parts, such as the Calumet region. The annual cost of works for carrying out this suggestion would be $122,000, considering an income from the additional flow of 4,000 cu. ft. per second. But this expenditure does not provide any relief whatever for the Calumet area, the cost of which, for filters, can be taken at $600,000 per annum when the population in the district is 700,000, while the cost of the Calumet-Sag project would be only $175,000 per annum.

The most important objection comes from the International Waterways Commission, which says that the diversion of 14,000 cu. ft. per second would lower all of the lakes from 6 to 8½ in., and that the cost of restoring the original depth would be about $12,500,000. It grants the diversion of 10,000 cu. ft. per second without further question for sanitary purposes, whatever the effect upon navigation may be, but recommends that the government of the United States prohibit the diversion of any further amount. Should the Sanitary Canal cause the lowering of the lake levels stated above, the prohibition would certainly be in the interest of Chicago no less than those of the entire lake region. It seems evident to Mr. Hering, however, from a study of the facts in the case, that whatever lowering would be caused by the diversion through the sanitary canal is already almost completely compensated by work partly done, or recommended to be done, by the Commission at Sault Ste. Marie.

The Commission has recommended the establishment of a low-water level in Lake Superior of 601.7 ft. above tide, to be held by regulating works, and a high water-level of 603.2 ft., or 18 in. higher. The lowest annual mean level of Lake Superior occurred in 1879, and was 601.43 ft. The most protracted low-water period since 1860 occurred between the years 1888 and 1893. During this period the lowest annual mean discharge at Sault Ste. Marie was 57,420 cu. ft. per second in 1892.

Computing from these facts the depth of storage necessary, after allowing this discharge to continue down the lakes, to furnish in addition a continuous flow of 14,000 cu. ft. per second to be diverted into the Mississippi Valley at Chicago, Mr. Hering finds this depth to be 21.6 in. If we add this depth to the lowest annual mean level of Lake Superior, which, since 1860 was 601.43, we get an elevation of 603.23, or but a trifle higher than the high water level recommended by the Commission. Therefore, its recommendations, if adopted, would create by storage during high water in the lake, Mr. Hering asserts, almost the entire flow of 14,000 cu. ft. per second desired by Chicago for its two sanitary canals, without lowering the lakes in the least, nor requiring any expenditure for restoring the original depths of the harbors, channels and canals of the lake system.

Other countries spend large sums of money for water storage to increase the flow of rivers. Our Great Lakes, Mr. Hering points out, are the most magnificent storage reservoirs of the world, high above ocean level and large enough to send, by gravity, great amounts of water to the sea in two directions for the benefit of commerce. Assuming now that there cannot be an injury to navigation in the Great Lakes from the diversion in the proposed sanitary canals, a few collateral facts of the Calumet-Sag Canal over the use of sprinkling filters are mentioned by Mr. Hering.

A final disposition of sewage by at once diluting it with a sufficient quantity of running water has the advantage, he states, of simplicity in operation, and is therefore always preferable to any method of treatment because it requires less attention, care and labor, and from a sanitary point of few, is quite as satisfactory, if the sewage is properly mixed with the diluting water and not used as a potable supply until actual oxidation has made it safe.

As yet the least expensive method of sewage treatment has not been developd to a final state. No municipal plant of sprinkling filters has yet been operated in America, although several are now under construction. We may, therefore, expect that experience, particularly in northern climates, may indicate some desirable modifications, Mr. Hering states, although we expect them to be only slight and in southern climates insignificant. On the other hand, the dilution method of sewage purification being the prevailing one and the oldest one in use, is thoroughly known as to what it can do and what it cannot do. We may, therefore, consider its works to be more permanent, Mr. Hering asserts. Even if the comparison of cost, simplicity and permanence, contrary to fact, had all indicated no distinct advantage for the dilution project, the present case introduces a feature which constitutes a decided advantage in favor of the Calumet-Sag canal. Its size, location and moderate current necessarily combine to make it available for a navigable waterway connecting Lake Michigan with the present sanitary canal at Sag. That there is already a marked tendency to concentrate heavy and bulky freight at the Calumet River is shown by the fact that, while the tonnage of the Chicago River has remained almost constant for 18 years, the annual increase of tonnage of the Calumet River has been quite rapid and is now more than half of that in the Chicago River.

If regulated for slack water navigation, it is well known that silt-bearing rivers have the disadvantages of perpetual dredging. If regulated for large quantities of lake water to materially augment the flow, such dredging will be much reduced and cause a permanent advantage. This view is endorsed and amplified by a remark made in Chicago in 1906 by General O. H. Ernst, Corps of Engineers, U. S. A., who said: "In a future not remote, larger amounts of water (than 10,000 cu. ft. per second) may be needed for sanitary purposes, and channels deeper than 14 ft. will then become practicable in the open alluvial portions of the Illinois River."

After weighing carefully all the advantages and disadvantages of the two propositions, it is Mr. Hering's opinion that the proposed Calumet-Sag Canal is not only the more economical one for disposing of the sewage of the Calumet region, but that it has still other advantages of more or less weight.

Sinking Viaduct Piers with Hydraulic Jacks.

The double track Market St. viaduct of the Philadelphia Rapid Transit Co., joins the Schuylkill River Bridge on a curve and the end tower, carrying a part of the approach span, has two piers, the most heavily loaded of which has about 13½ tons dead and 49½ tons maximum live load. They are located about 60 ft. beyond the water line and were sunk about 40 ft. through miscellaneous fill to coarse gravel with steel cylinders 4 ft. in diameter and 60 ft. long.

Jacking Down a Pier Cylinder for a Viaduct.

Reaction Beam for Jacking Down a Cylinder.

An excavation about 10 ft. wide and 30 ft. long was made adjacent to the masonry abutment, and was sheeted down about 10 ft. to water line on three sides with 2x10-in. vertical planks driven against horizontal rangers 5 ft. apart, strongly braced with transverse struts. An 8x12-ft. horizontal platform of 10x10-in. timbers laid on pairs of transverse 12x12-in. girders were set, one on each side of each cylinder pier center and provided with four vertical 1½-in. rods about 12 ft. long with their lower ends passing through the platforms and girders and bearing against the under sides of the latter with nuts and washers. The upper ends passed through 12x16-in. longitudinal horizontal timbers 10 ft. long and took bearing on their upper surfaces with double nuts and heavy cast-iron washers.

Between the rods a 16x16-in. transverse timber, 5 ft. long was seated across the tops of the lower timbers and connected to them with two pairs of 1½-in. bolts, engaging four 5-in. saddle plates on the tops and bottoms of the timbers. A pair of horizontal longitudinal 12-in. I-beams about 20 ft. long were set on the center transverse line of the bents with their top flanges between the pairs of 12x16-in. timbers with their top flanges bearing against the lower surfaces of the 16x16-in. upper timbers, and served as reaction girders for sinking the cylinders.

The platforms were loaded with more than 50 tons of pig iron, and a hydraulic jet was inserted in the cylinder, jacking beams were placed across its upper end and on them were seated a pair of 50-ton hydraulic jacks engaging the lower flanges of the reaction girders. The jet was moved around the interior of the cylinder close to the cutting edge and its scouring action combined with the pressure of the jacks, each operated by two men at its lever, gradually forced the cylinder into the ground while the sand and water overflowed its upper edge, was collected in a sump and drained by a steam pump.

When the first section was driven to the surface of the ground the jacks were removed, a second section was bolted to it through interior flange connections, the jacks were replaced and operations repeated until both cylinders were sunk 6 ft. farther, after which a third section was added, and so on until the continuous steel shell entered the gravel stratum and was pumped out. Men then entered, cleaned and leveled the bottom and rammed the dry 1:3:5 concrete with which the cylinders were filled.

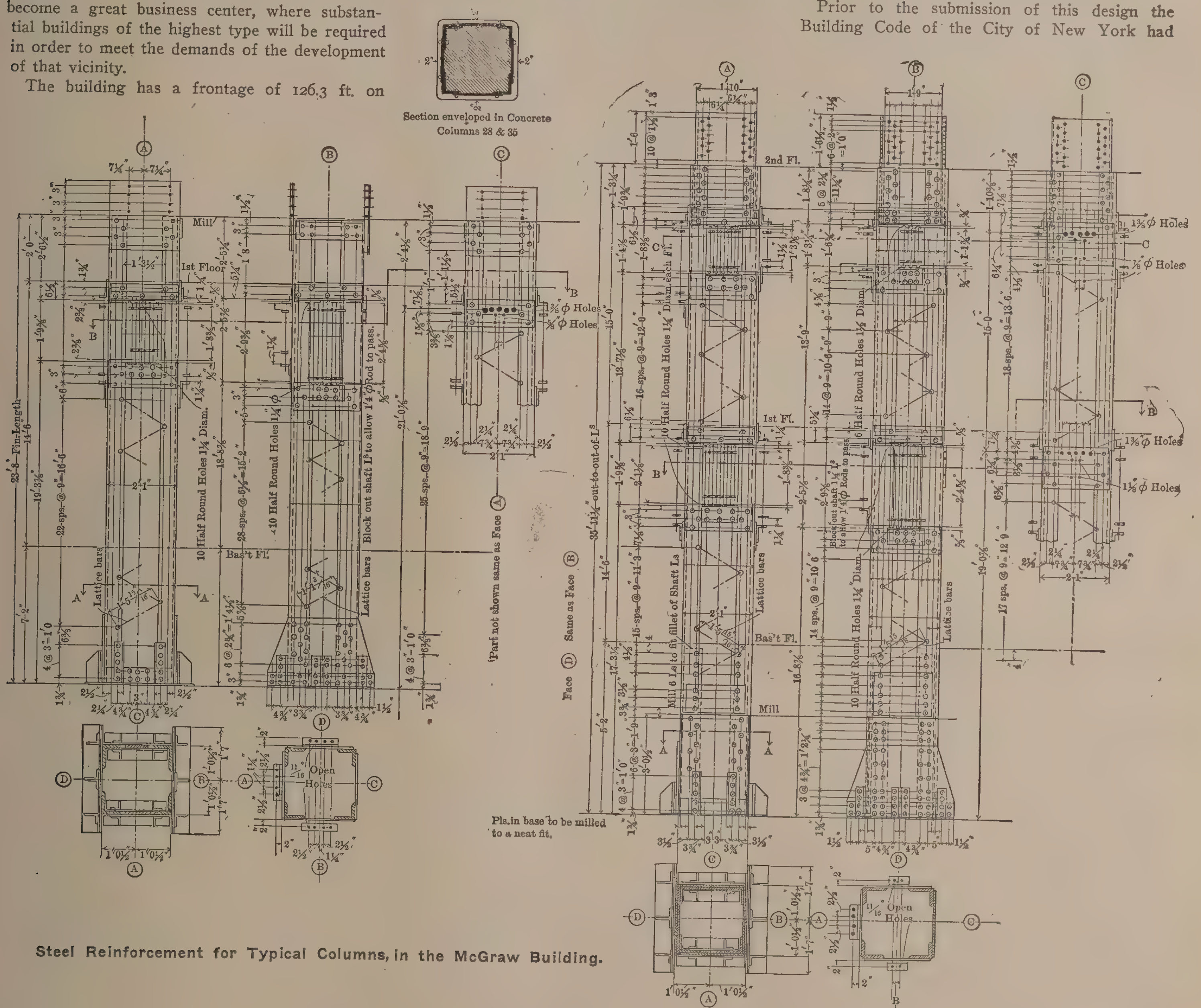
The fill contained so many boulders and other obstructions that about two days were required for sinking each section of a cylinder, but the cylinders for both piers were sunk simultaneously. This method of sinking is, of course, not unusual in building construction, but in this case the conditions were difficult and it was believed that a considerable economy was effected by using this method instead of the ordinary pneumatic caisson method. The work was done by John Monks & Sons, New York, Mr. Chas. Deans, engineer, under the direction of the engineering department of the Philadelphia Rapid Transit Co., Mr. W. S. Twining, chief engineer, and Mr. Chas. M. Mills, principal assistant engineer, and Mr. Frank R. Fisher, resident engineer.

Apokonin is a new dust-preventing material described in a recent report from Consul Norton at Chemnitz. He states that it is a mixture of heavy residual oils obtained in the distillation of coal tar with high-boiling hydrocarbons. The product thus made is prepared for use by heating it in iron kettles, like those employed with asphalt, to temperatures ranging from 212° to 250° F. It is then sprayed evenly over the roadway with a special sprinkler, which operates under such high pressure that the liquid penetrates the upper layer of dust. As a result a compact shining black coating is said to be formed which has no odor and is dustless. This material has been used on the macadamized streets of Leipsic to some extent.

The Reinforced Concrete Work of the McGraw Building.

A paper by William H. Burr, in the "Proceedings" of the American Society of Civil Engineers for October, 1907, to be presented Nov. 20, 1907.

The McGraw Building is a true reinforced concrete structure—the latest type of buildings of that general class. It is on the north side of West 39th St., between Seventh and Eighth Aves., in the city of New York, in that district which has already felt the stimulating influence of the new Pennsylvania R. R. Station in process of construction a half dozen blocks to the south. This part of the city is undoubtedly destined to become a great business center, where substantial buildings of the highest type will be required in order to meet the demands of the development of that vicinity.


Section enveloped in Concrete Columns 28 & 35
2"
2"
Mill
1st Floor
Bas't Fl.
2nd Fl.
1st Fl.
Lattice bars
10 Half Round Holes 1¼" Diam.
10 Half Round Holes 1½" Diam.
Block out shaft 1" to allow 1¼" φ Rod to pass.
1⅜" φ Holes
⅞" φ Holes
Part not shown same as Face Ⓐ
Face Ⓓ Same as Face Ⓑ
Mill 6 Ls to fit fillet of Shaft Ls
33'-11¼" out-to-out of Ls
23'-8" Fin. Length
Open Holes
Pls. in base to be milled to a neat fit.
Ⓐ
Ⓑ
Ⓒ
Ⓓ
A
B
C

Steel Reinforcement for Typical Columns, in the McGraw Building.

The building has a frontage of 126.3 ft. on 39th St., and a depth of 90 ft. It has eleven stories. The height of the roof is 145 ft. above the ground floor, or nearly 150 ft. above the street, or, finally, 159 ft. 6 in. above the basement floor. While, therefore, it is far from ranking among the tallest sky-scrapers of the city, it is to be classed among the high business buildings of Manhattan Island. Its height is much greater than has heretofore been considered practicable for a purely reinforced concrete building, i. e., a concrete building without iron or steel columns.

It has been constructed for the McGraw Realty Co. primarily to accommodate the business of the McGraw Publishing Co., whose publications include "The Enginering Record," "Electrical World" and "Street Railway Journal." At the same time is was designed to accommodate not only the printing presses of the McGraw Publishing Co., but any other similar business requiring the operation of heavy machinery or the storage of heavy goods in bulk. It was imperatively necessary, therefore, that the building should be designed and built so as to afford the greatest possible resistance to the vibration of heavy machinery, and possess to an unusual degree both rigidity and durability. It is also fireproof to such an extent that the McGraw Realty Co. may reasonably be its own insurer. While the building is admirably adapted to office use, its lower floors, particularly, are thus capable of affording provision for those business purposes which require heavy and substantial construction.

Like most other portions of that part of the city north of 14th St., the rock originally at the site of the building was close to the surface. The excavations for the foundation were not carried deeper than about 20 ft. below the street surface, and there the entire foundation was placed upon the gneiss which forms the ledge or bedrock. There were no real foundation problems to be solved. The columns supporting the building, and the retaining or area walls around the basement, were all founded upon the same ledge, under the requirements of the Building Code of the City of New York.

In order to meet the exacting requirements for the unusually substantial structure required by the McGraw Publishing Co., it was decided to design the building for a live load of 250 lb. per square foot for the first and second floors, 200 lb. per square foot for the third floor, 150 lb. per square foot for the fourth floor and 125 lb. per square foot for all the other floors above the fourth, and with a live load of 60 lb. per square foot for the roof. All parts of the floor beams and girders, therefore, and the columns, were designed to sustain, under the requirements of the Building Code, the actual weight of the structure and the live load specified above.

Prior to the submission of this design the Building Code of the City of New York had permitted a working stress of only 350 lb. per square inch, for concrete in direct compression, it being practically assumed that all reinforced concrete columns would be of the Considère type. Obviously, if this regulation should prevail for an eleven-story building, the size of the columns in the basement and lower stories would be so great as to trench too seriously upon the available space for machinery or for other business purposes. As it was strongly desired to secure all the material advantages accruing to reinforced concrete structures, it became necessary to design such columns as would be of much smaller cross-section than those of the type heretofore prevailing. Two procedures were available: one was to use a substantial quantity of steel in the form of an ordinary steel column suitably designed for this purpose, and the other was to use the concrete in such a way as to justify a much larger working stress per square inch than that prescribed in the Building Code. These requirements are met in an eminently satisfactory way by the columns of the type used. All columns throughout the building are composed of an interior filling of concrete combined with steel angles latticed in the ordinary manner of built steel columns. The interior columns and most of those in the exterior walls are built with four angles, with the usual riveted lattice or lacing bars on the four sides of each column. In the case of a number of the exterior columns it was necessary, for the attainment of unavoidable structural ends, to use a column of elongated cross-section with eight steel angles of the same general type as those in the interior, which, with the concrete filling, form a column of two cells, so to speak, rather than one. The plans accompanying this paper show fully and clearly this arrangement of the combined concrete with steel angles and lacing bars. In all cases the steel angles, with the corners of the angles turned out, were spaced as far apart as the extreme outer dimensions of the completed column would permit.

In accordance with the requirements of the Building Code, there is a thickness of 2 in. of concrete outside of the steel angles. This 2-in. shield of concrete is assumed to carry no load whatever; its function is simply that of fireproofing, i. e., to protect the steel against the immediate heat or flames of any fire that may start in the combustible materials at any time stored in the building, or of a conflagration in an adjoining building. The concrete within the exterior dimensions or outline of the steel angles is available for carrying a compressive or column load. As it is completely embraced or surrounded by the steel angles and lacing bars, it is steel "banded" in the most effective manner possible. Its enclosure in the steelwork of the column is so rigid, manifestly, that lateral strains under column loads must be greatly reduced—in fact, nearly prevented—within any ordinary limits of loading. Such concrete, therefore, is largely prevented from the usual yielding of that material under compression, and its compressive carrying capacity is increased. This is not only obvious from the condition of the concrete in these columns, but that view is confirmed by the comparatively few results of tests of concrete columns of this character. When, therefore, the plans of these columns were submitted to the Bureau of Buildings of the City of New York for examination and final approval, a special regulation was made permitting the concrete to carry a maximum working load of 750 lb. per square inch within the exterior limits of the steel angles, the exterior 2 in. of concrete, as stated previously, being considered simply a fire-protecting shield. This increased permissible load upon the concrete is coupled with the further provision that the cross-section of the steel in any column at any floor shall be sufficient to carry the entire dead load above that section without stressing the steel to more than 16,000 lb. per square inch.

The use of the steel, in load-supporting condition, as a long column independent of the concrete, and at the same time forming a rigid banding member for the latter, with the consequent increase of permissible working load on the concrete, reduced the size of the columns in the basement and lower stories to dimensions quite consistent with the desired convenient and economical use of the clear floor space. Columns of this general type combine with their high carrying capacity, great convenience in erection, for their steel sections may be erected ahead of the concrete work and afford convenient supporting members for the adjoining forms or for other erection work. The lacing bars, rivet heads, and other projecting column details act positively in creating a firm and complete hold or bond between the steelwork of each column and the concrete enclosed within it. This feature of these columns compels the steel and the enclosed concrete to act as a unit, and this action is enhanced by placing all the lacing bars in one direction inside the steel angles, the other set being placed outside, as shown on the plans.

The Building Code requires the ratio between the moduli of elasticity for the steel and concrete to be taken as 12. Hence, as the permissible compressive working stress in the concrete was taken at 750 lb. per square inch, the corresponding working stress in the steel would be 9,000 lb. per square inch.

The largest columns (in the basement) have exterior dimensions of 29 x 29 in., but, at the eleventh story, the exterior dimensions are reduced to 14 x 14 in. These columns were built in sections of a length equal to the combined height of two stories, i. e., 25 ft. The extra metal involved in this procedure was too small to be of practical consequence, and the expense of half the joints, if a change of section had been made at every floor, was saved. Much time was also gained in the erection of the steelwork. The abutting ends of the column sections were faced, and the joints were made by suitable splice-plates. Where there was a change in the exterior dimensions of the steelwork, full-strength splices were made by riveting suitable short-angle sections on the interior of the splice-plates of the lower part of the joint. These details are also shown on the plans.

Table 1. Sizes of Steel Angles in Columns, and Outside Dimensions of Steel Columns, *i. e.*, Back to Back of Angles.

Floor.				
11........	4 L's, 2½ x 2½ x 5/16 in. 10 x 10 in., b. to b.	4 L's, 3½ x 3½ x 9/16 in. 10 x 10 in., b. to b.	4 L's, 2½ x 2½ x 5/16 in. 12 x 26 in., b. to b.	4 L's, 2½ x 2½ x ⅜ in. 12 x 26 in., b. to b.
10........	4 L's, 3 x 3 x 7/16 in. 17 x 17 in., b. to b.	4 L's, 3½ x 3½ x 9/16 in. 10 x 10 in., b. to b.	4 L's, 3 x 3 x 7/16 in. 12 x 26 in., b. to b.	4 L's, 2½ x 2½ x ⅜ in. 12 x 26 in., b. to b.
9........	4 L's, 3 x 3 x 7/16 in. 17 x 17 in., b. to b.	4 L's, 3½ x 3 x ⅝ in. 17 x 17 in., b. to b.	4 L's, 3 x 3 x 7/16 in. 12 x 26 in., b. to b.	4 L's, 3 x 3 x 9/16 in. 12 x 27 in., b. to b.
8........	4 L's, 5 x 3 x 11/16 in. 18½ x 18½ in., b. to b.	" " " " " "	4 L's, 3½ x 3 x ⅝ in. 12 x 28 in., b. to b.	" " " " " "
7........	" " " " " "	4 L's, 6 x 4 x ¾ in. 18½ x 18½ in., b. to b.	" " " " " "	4 L's, 3½ x 3½ x 11/16 in. 12 x 29 in., b. to b.
6........	4 L's, 6 x 4 x 13/16 in. 20½ x 20½ in., b. to b.	" " " " " "	4 L's, 5 x 3½ x ⅝ in. 12 x 30½ in., b. to b.	" " " " " "
5........	" " " " " "	4 L's, 6 x 6 x 13/16 in. 20½ x 20½ in., b. to b.	" " " " " "	4 L's, 5 x 3½ x 11/16 in. 16 x 32 in., b. to b.
4........	4 L's, 6 x 6 x ⅞ in. 22 x 22 in., b. to b.	" " " " " "	4 L's, 6 x 4 x 11/16 in. 16 x 33½ in., b. to b.	" " " " " "
3........	" " " " " "	4 L's, 8 x 6 x ⅞ in. 22 x 22 in., b. to b.	" " " " " "	4 L's, 6 x 4 x 13/16 in. 16 x 35 in., b. to b.
2........	4 L's, 8 x 6 x 1 in. 24 x 24 in., b. to b.	" " " " " "	4 L's, 6 x 4 x ⅞ in. 16 x 36½ in., b. to b.	" " " " " "
1........	" " " " " "	4 L's, 8 x 6 x 1 in. 25 x 25 in., b. to b.	" " " " " "	4 L's, 6 x 4 x 15/16 in. 16 x 38 in., b. to b.
Basement.	4 L's, 8 x 6 x 1 in. 25 x 25 in., b. to b.	" " " " " "	4 L's, 6 x 4 x 15/16 in. 16 x 38 in., b. to b.	" " " " " "

The ratio of the area of steel section to that of the concrete for the various columns varied from 10 per cent. in the basement where the steel carries about 57 per cent. of the total load to 3½ per cent. in the ninth floor where 30 per cent. of the total load is carried by the steel. The requirements of the Building Code for a design of this type raises the percentage of steel to much higher values than in ordinary concrete-steel work.

Table 1 shows the number and sizes of steel angles used throughout the main columns of the building.

The design of the floors, in general, is quite similar to that usually found in buildings of this class, although there are certain important details which do not come under that observation. As the plans indicate, the spacing of the columns is such as generally to divide each floor into panels 21 ft. 9 in. by 14 ft. 8 in. between centers of columns, the clear span of the main girders between columns being 14 ft. 8 in. less the width or diameter of the column section. The clear span of the floor beams between the main girders is 21 ft. 9 in. less the width of these girders. These prevailing lengths of spans of the beams and girders were modified at a few points in each floor to accommodate such features of construction or details of floor space as stairways, elevator shafts and similar details.

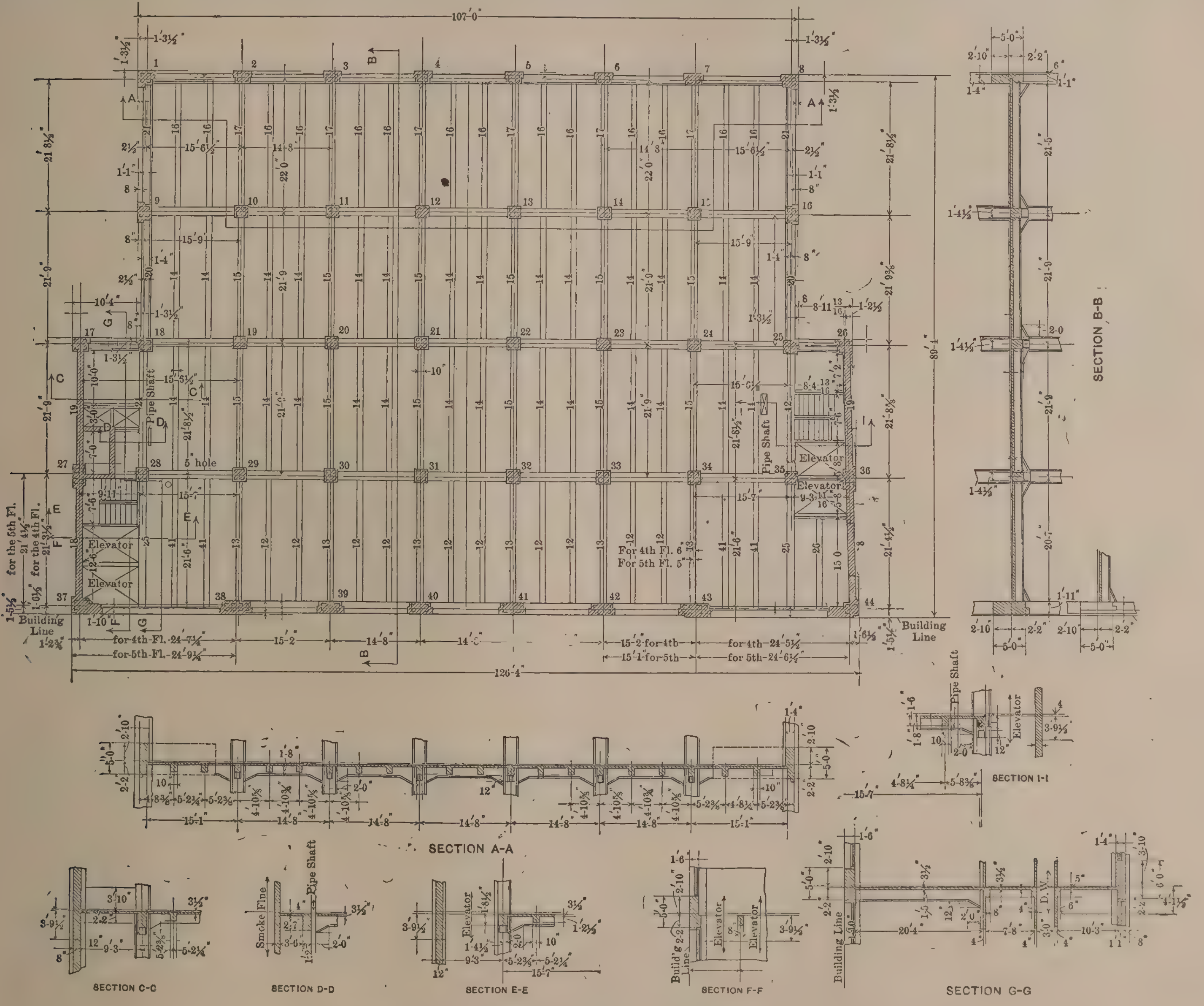
As the plans indicate, all floor-girder and beam reinforcement was of round steel rods, of sizes running generally from ¾ to 1⅜ in. in diameter. These rods were grouped in one plane on the tension side of each beam or girder. As a rule, every alternate rod was bent upward at the end of each span so as to rise within about 2 in. of the top of the concrete, from which point it continues through either the main girder or the adjoining column, as the case may be, into the adjoining span well toward the quarter point of the latter. By these means, true continuity of beams and girders was secured in every case. In addition to this, the end of each rod was bent down, forming a right-angled turn, with an arm from 2 to 3 in. long, thus insuring a rigid bond or connection with the concrete. This main detail, formed by carrying the rods through the girders and columns, is an important feature in securing continuity and rigidity in the general construction of the building. It is believed to be one of the most important details of the best design of reinforced concrete building construction, and it should be secured either in the manner adopted in this building or by some other procedure of at least equal excellence.

The proper spacing of these reinforcing rods was secured by suitable supporting details throughout the length of the beams and girders themselves and by notches cut in angle-brackets riveted on the columns where they joined the latter members. At the columns, rigidity of connection was secured by bolting clamps through the angle-brackets just named and jamming the rods by tightening the nuts against those brackets. This secured an exceedingly strong metal connection between the reinforcing rods and the steel columns, aside from the further rigidity produced by the concrete mass of the intersecting columns, beams and girders. These details, shown on the plans, were designed with care for the purpose of securing the strongest possible steel connections between the beams or girders and the columns, it being one of the main purposes to attain rigid continuity between floors and columns, and floors and outside walls. It is believed that unusual stiffness and strength have been given to this building by these means.

All beam and girder computations required by the floor designs were made in accordance with the provisions of the Building Code of the City of New York, the usual common theory of flexure formulas for concrete-steel beams being used.

While the parabolic law of variation of intensity of stress in concrete beams results in a trifling economy of material, it is less rational and simple than the usual straight-line law of variation, and the latter is more nearly accurate.

The Building Code of New York does not permit the condition of perfect continuity of beams to govern the design of reinforced concrete floor beams and girders. It is permitted, however, to consider the maximum bending moment of such beams, when uniformly loaded from end to end, as the total load multiplied by one-tenth of the span, rather than one-eighth of the span as would be taken were the beams simply supported at each end. This is a widely used method for continuity, in favor of which much can be said. It is extremely doubtful whether perfect continuity is attained in any case, but it is certain that a material advantage is secured over the condition of a beam simply supported at each end. The one-tenth rule, as it may be called, is a reasonable compromise.



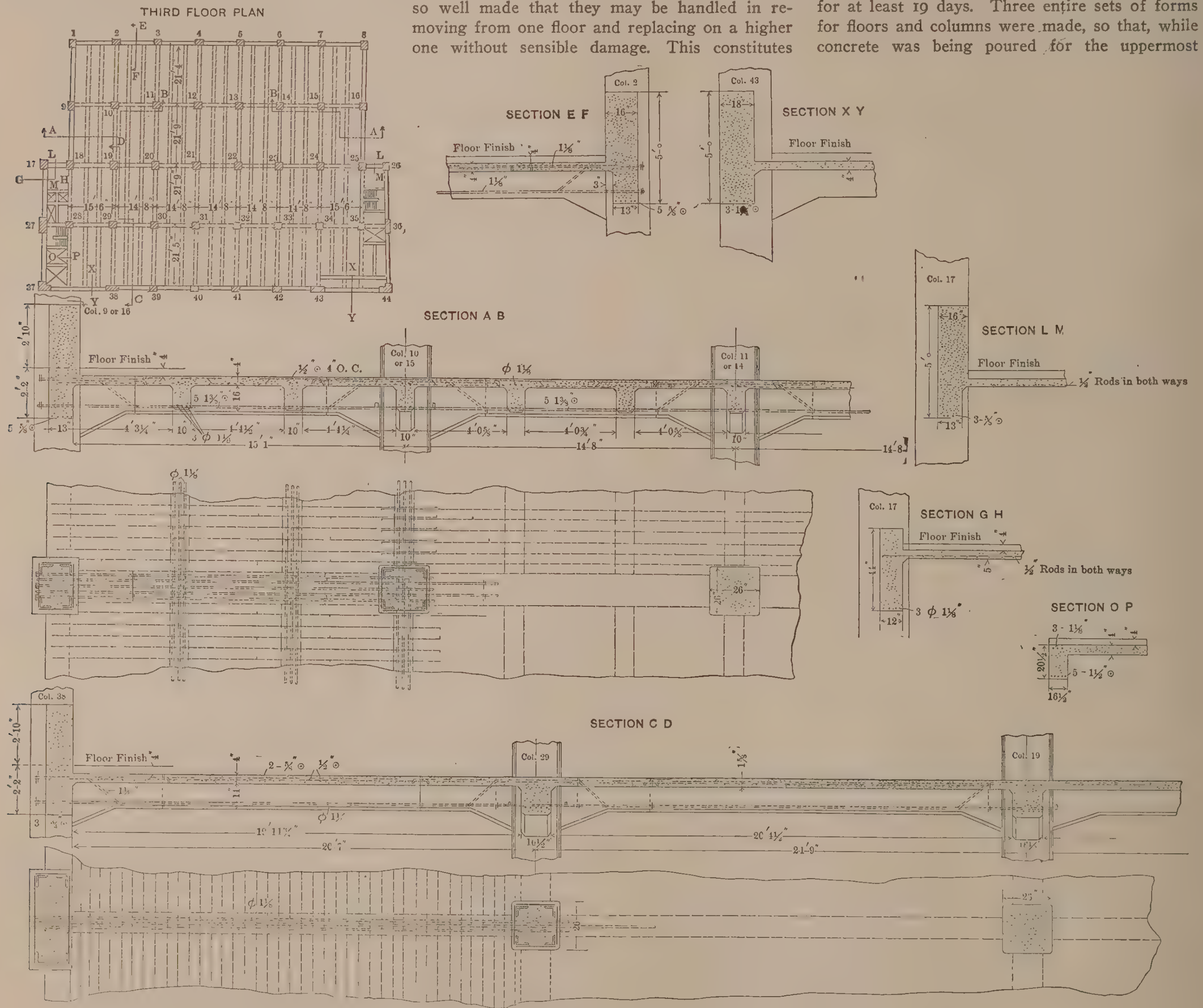
General Plan and Sections of Typical Floor, McGraw Building.

Another condition insisted upon in the design of this building was a metallic provision for taking the end shears of beams and girders. By referring to the plans there will be observed inclined portions of the round steel reinforcing rods to which attention has already been called. In every case there is sufficient steel in these inclined portions of rods to take the total end shears multiplied by the secant of the inclination rods to a vertical line without stressing the steel to an unsafe extent. While the tension in the steel produced in this manner, ignoring entirely the shearing resistance of the concrete, is higher than would normally be prescribed, it is far below the elastic limit, and forms a safe provision for the entire end shear in case any exigency should arise producing such a break in the concrete as practically to destroy its capacity for shearing resistance. In addition to this condition, there is sufficient concrete also at the ends of beam and girder spans to carry the shear at an intensity of 50 lb. per square inch of concrete section as permitted by the New York Building code. This, also, has been considered one of the essential details of a concrete-steel building designed for a heavy and otherwise fatiguing service.

The floor slabs spanning the spaces between the floor beams are 4 in. thick in the lower floors, carrying the heaviest loads, and 3½ in. thick in all the higher floors. Their reinforcements are ½ and ⅝-in. rods, long enough to extend over a number of panels or spans so as to make these also continuous. Their general design is similar to that of the floor beams and girders. As the distance apart of the centers of the floor beams is about 5 ft. 2 in., the clear span of these floor slabs varies from about 4 ft. to a little more than 4 ft. 4 in., according to the thickness of the adjoining floor beams on either side of the span.

The proper design of the wooden forms or moulds for a concrete steel building, in order to secure expeditious and economical work, is the most difficult part of the entire undertaking, and the principal improvements to be made in it are those which pertain to perfecting a proper system of construction of the forms and their ready handling. The quantity of lumber required in them, and the carpentry work necessary in making repairs consequent upon their use and re-use for successive floors, and in their supports, constitute far larger items of cost than might at first be supposed. If these costs are to be reduced, as they must be for heavy concrete-steel construction of the best class, the principal study of the engineer must be directed to this particular part of his work. While these ends may not and probably have not been completely attained in this instance, the system of forms used gave excellent results in the quality of the concrete produced, and led to reasonable economy and efficiency. The weight of concrete and the relatively large quantities used in such individual members as beams, girders and columns make heavy forms imperative and substantial support necessary.

The details of the timber forms for the floor beams and girders where they meet the column forms require especial attention. A proper design of the parts where the floors and columns join will result in great economy in the details of the forms. If the shapes of the exterior surfaces of the concrete are complicated and require careful fittings of the column and floor forms, expensive carpentry work will be required wherever a column pieces a floor, whereas simply shaped concrete surfaces will eliminate that work and greatly expedite the construction. Similarly, it is highly desirable that there shall be as few changes as possible in the exterior dimensions of the columns. If exterior column dimensions could be retained unchanged from basement to roof, it would make possible complete uniformity of the details of column and floor forms throughout the entire building, eliminating a great amount of fitting and carpentry work otherwise unavoidable.



Plan and Sections of Typical Floor Beams and Girders Showing Steel Reinforcement.

It is obvious that it is essentially impossible to retain uniform exterior column dimensions throughout the series of floors from the bottom to the top of the building, but the most scrupulous care should be exercised to make these changes as few as possible and in such a way as to reduce to the utmost extent changes of details in the forms.

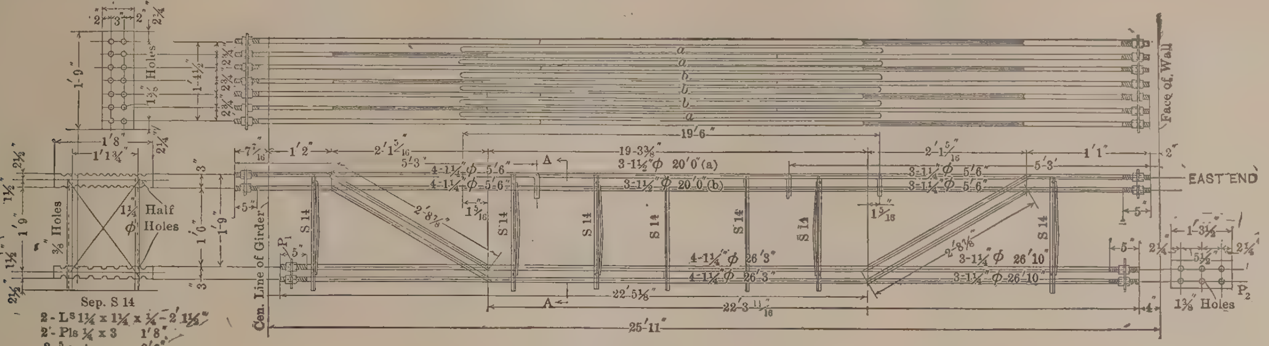
A reference to the plans will show that the floor forms between the beams consisted of large shallow boxes with truncated corners between the sides and the bottom. They were placed bottom up on stable supports and separated by the thickness of the adjoining floor beams at the sides and by the thickness of the main floor girders at their ends. The bottom of the opening between the adjoining sides of any two of them was then suitably closed with planks or boards so that when the concrete was finally poured over their tops to the thickness of the floor slabs, the desired paneling of those slabs between the beams and girders was secured. It is imperative, for expediting the work, as well as for economy, that these box forms for the floors shall be constructed so that they may be removed readily after the concrete becomes sufficiently hard. To secure this important result, such forms must be readily collapsible at both ends and sides, and, at the same time, they must be substantial enough to hold the wet concrete without distortion and so well made that they may be handled in removing from one floor and replacing on a higher one without sensible damage. This constitutes one of the most essential points in the design of these forms, which, in this case, were collapsible although perhaps not as freely as might be desired. When the forms stick to the concrete in the process of removal laborers use sledges and iron bars, driving the latter between the new concrete and the forms and making a fulcrum of the former. This results in seriously marring what might otherwise have been a highly satisfactory concrete surface. The same general observations apply to the forms for the columns. Whenever the art of reinforced concrete construction is brought to the high state of excellence which it must ultimately reach through a proper design of the forms, making their erection, support and removal expeditious and free, the labor bills for the work and the repairs of the forms themselves will be so greatly reduced as to give this class of construction material economic advantage.

The length of time which the forms should remain in place supporting fresh concrete will depend on the temperature, and hence on the season as well as on the character of the work designed. It is clear that, with the substantial steel reinforcement of the columns of this building, a minimum of time would be sufficient for the column forms, but as it was not convenient to remove the latter until the floor forms were also ready to come down they were all kept in place for at least 19 days. Three entire sets of forms for floors and columns were made, so that, while concrete was being poured for the uppermost floor being constructed, the two stories immediately below were still supported by the timber forms. The lowermost set of forms was then taken down and placed above the freshly formed concrete last put in place. In this manner the forms could be left in place long enough to satisfy the requirements of even the Winter season.

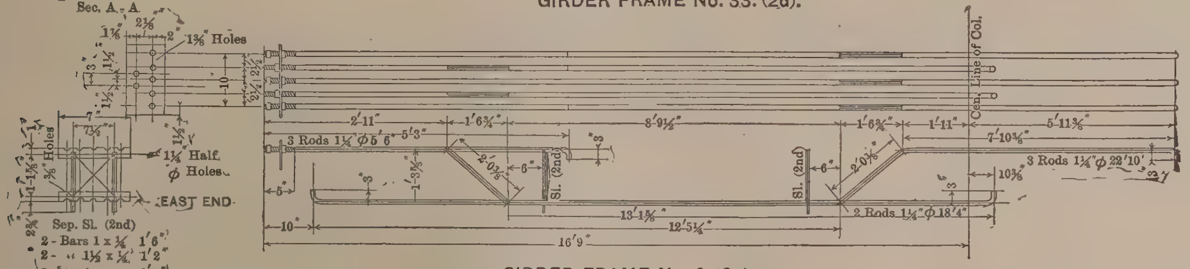
The concrete work of the building proper was begun in the basement in September, 1906, and the concrete parapet walls on the roof were carried on almost uninterruptedly throughout the Winter. A few of the coldest and stormiest days of the Winter were sufficiently severe to cause the work to be suspended for the day. When it is remembered that from the latter part of January until the early part of March the weather was phenomenally severe, it is demonstrated by actual experience that reinforced concrete building work may be conducted under proper conditions through a New York Winter without material interruption.

After the completion of the lower two or three stories, when the organized force had become accustomed to the character of the work and the sequence of operations required, the average rate of progress, including the delays and occasional interruptions caused by the Winter weather, was about twelve calendar days to a story.

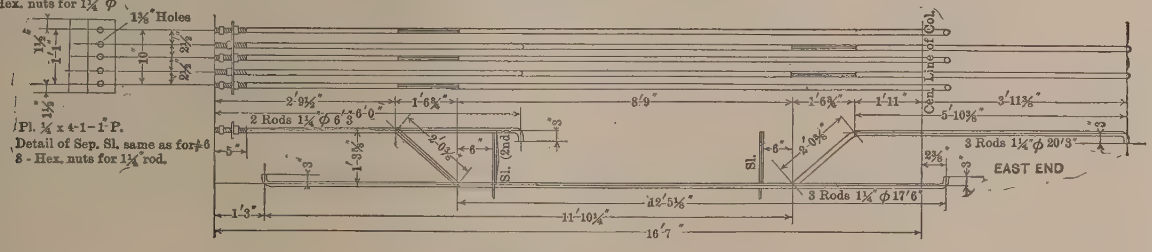
From the early part of December to the latter part of March the window openings of the story below the floor in process of construction were closed with canvas, behind which, distributed over the entire floor, salamanders burning coke were constantly kept in operation. These salamanders were to some extent concentrated under the freshly poured concrete. By these means entirely satisfactory temperatures could be maintained, so that the retarding influence of the frost on the setting of the concrete was to a great extent eliminated, except for the fact that occasionally the top surface of the fresh concrete was frozen. The warmest air produced by the salamanders would rise to and remain in the overhead cellular spaces of the timber floor forms and act there with a high degree of efficiency.



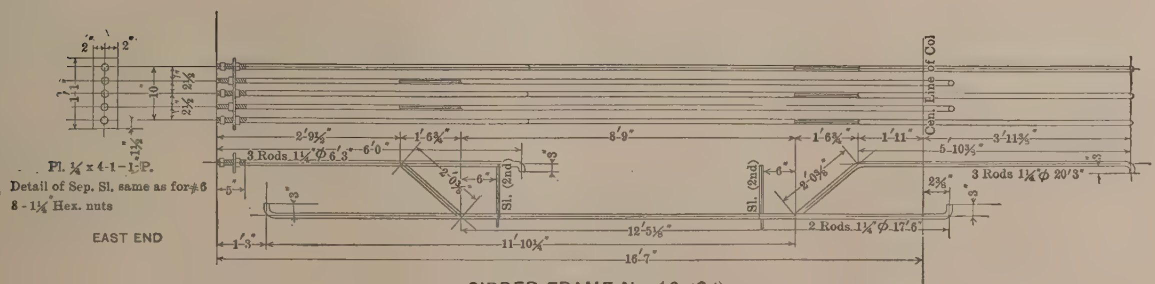
GIRDER FRAME No. 33. (2d).



GIRDER FRAME No. 6. (2d).



GIRDER FRAME No. 8. (2d).



GIRDER FRAME No. 10. (2d).

Steel Reinforcement of Typical Girders, McGraw Building.

In connection with the operation of the salamanders below the fresh concrete, the top of the latter, as fast as poured, was always protected by a covering of hay or canvas, or both. These protective measures were scrupulously enforced throughout the winter with entirely satisfactory results. Indeed, there was no evidence to be found throughout the whole building to show that any part of the concrete whatever was affected injuriously to the slightest extent by the frost. During a considerable portion of the winter a few salamanders were kept burning in the second floor below the work in progress.

All the construction work of the building was carried on from a high central temporary timber tower running from the basement to a height of nearly 75 ft. above the roof. This timber tower was 31 ft. square and built with 10x10-in. yellow pine spliced corner posts properly braced. Each 10x10-in. corner stick carried a derrick boom 75 ft. in length. These derricks were first placed low down on the tower, and then raised from time to time to elevations required by the progress of the work. The booms were long enough to command the entire area of the work, and had a sufficient swing or reach to pick up material, including sections of the steel columns, delivered in the street in front of the building, and put it in its proper permanent place. The hoisting engines were placed in the basement, and steel cables ran from them up to the derricks.

It was a question at first whether the cost of this tower and derricks was justified by the amount and character of the work to be done, but they were found to be fully justified and well adapted to their purpose. It was probably as economical and expeditious a method as could have been devised for handling the materials and serving the work. As the building was carried up, the work within the limits of the tower was completed, with the exception of the points where the corner 10x10-in. sticks pierced the respective floors where enough free room was left for the operating cables. After the concrete work was finished the tower was taken down through the succeeding floors of the building, and the holes left for the corner posts were filled.

There was nothing unusual about the character of the materials used throughout the building. The material and workmanship of all the steelwork were supplied and manufactured under Cooper's Specifications. The Portland cement used was the Dragon brand, and it was tested and supplied under the standard specifications recommended by the Special Committee of the American Society of Civil Engineers. The sand, broken stone and gravel were supplied by different parties about the city of New York. Some of the broken stone came from the north, down the Hudson River, and most of the sand and gravel came from Long Island. Throughout the building proper, ¾-in. broken stone—trap rock and limestone—was used, with the exception of considerable quantities of gravel in which no pieces had a greater maximum diameter than about ¾ in. In some of the larger masses of the retaining walls and other similar parts of the foundation and basement of the building, 1½-in. broken stone was used.

The proportions of the concrete for the entire building were: One of cement, two of sand, and four of broken stone or gravel by volume. The consistency of the concrete was very nearly or quite wet enough to be that termed semi-liquid, so that it was truly "poured" into all forms for columns, walls and floors. Such a consistency of concrete is imperative for reinforced concrete construction of this class. It enables the concrete to form an intimate and dense matrix around the steel reinforcement, and produces a most excellent quality of material. While the concrete was being poured laborers with long thin sticks continually agitated the fresh concrete in order to release all air bubbles and insure a dense and continuous product and the best possible bond with the embedded steel. There was no sensible excess of water in the concrete, but it was practically semi-liquid—too thin even to quake. The results throughout the entire work, in this respect, have proved to be in the highest degree satisfactory. The total quantities of the principal materials used were: Cement, 8,500 bbl.; sand, 3,000 cu. yd.; broken stone, 4,300 cu. yd.; gravel, 1,066 cu. yd.; steel in angle columns, 655 tons, latticed; steel in round reinforcing rods, 507 tons.

Ornamental Foot Bridge in Bronx Park.

A handsome foot bridge of rubble masonry has been constructed recently in the New York Botanical Garden, Bronx Park, New York City. It is 110 ft. long from face to face of the abutments and is made up of three 20-ft. and two 16-ft. spans, one of the latter being at each end of the bridge. The piers have a uniform thickness of 7 ft. and are 29 ft. wide at the base and 27 ft. wide at the level of the springing lines, above which level they are curved in gracefully to meet the parapet walls. The arches are segments of circles and their thickness is uniformly 2½ ft. The parapet walls are 2 ft. thick and rise 3 ft. above the top of the foot path at the crown points of the arches. Weep holes are provided at each pier and a 6-in. layer of concrete, covered in turn with asphalt waterproofing, is laid over the entire upper surface of the arches and piers.

The bridge is built entirely of material selected from the old stone fences in the park which are gradually being destroyed. The stones forming the parapet walls and the exterior surfaces of the arches and piers were specially selected and disposed to make the best possible appearance. The facing stones of the arches are placed radially anad by selecting stones decreasing in length from the haunches to the crown, with a keystone at the center, a pleasing effect was obtained at little expense. In constructing the arches, to prevent the mortar from running down and entirely filling the interstices between the soffit stones, the latter were bedded in a layer of sand laid on the centering; when the centering was removed the sand dropped out and the outer surfaces of the stones were free from mortar as was desired. The bridge was designed and built under the direction of the Department of Parks, Borough of the Bronx, New York City, of which Mr. Martin Schenck is chief engineer, and Mr. W. P. Hennessy is assistant engineer.

Gas-Power Central Station of the Duquesne Light Co., Pittsburg, Pa.

A paper read before the American Institute of Electrical Engineers, Pittsburg Branch, by Norman C. MacPherson.

Although the territory now supplied by the Duquesne Light Co. was already covered by the distribution system of another company, there seemed to be room for further business for a central station securing the advantages of more uniform regulation and distributing directly from the center of gravity of its load, thus obviating the first cost, the maintenance, and the losses of long transmission lines. Work was begun on June 28, 1906, and by October 5 the power station and distribution system were far enough completed to start regular 24-hour service. During the following six months the service increased so rapidly that the station is now heavily loaded and running on an excellent load-factor. The service consists of residential and commercial lighting and power, and these merge into a load having an exceptionally long hour evening peak and a fairly even day load. The 60-cycle generators are wound three phase, star connected, and the distribution is partly underground and partly overhead to standard 2,200-volt transformers, which in turn are connected to 110/220-volt secondaries.

The power station. In the choice of site and equipment, several factors had to be carefully considered.

a. Proximity to electrical "center of gravity."
b. Coal supply for steam or gas plant.
c. Natural gas supply for gas plant.
d. Water supply for condensing or cooling purposes.

The power house site chosen—near the junction of Penn avenue and the Pennsylvania Railroad—is approximately the center of the system, extending as it does about two miles in every direction from this point. Although the Pennsylvania Railroad passing the property offered excellent fuel facilities, the absence of a natural supply of water in the East End practically barred a steam plant. The high pressure pipe line of the Pittsburg Natural Gas Co., delivering 24,000,000 cu. ft. of gas daily to the mill district of this city, passes within 1,000 ft. of the power house site, and this fuel was finally decided upon for its availability and cheapness. Should the natural gas ever fail or reach a prohibitive price, a producer plant will be erected on the company's adjoining property, the coal used being elevated from the Pennsylvania Railroad tracks. In this case the present engine equipment will be retained, as it is entirely adapted to either natural or producer gas—a good illustration of the flexibility of power gas work. In the building proper—a sub-station fire-proof structure of brick, concrete and steel—the one feature out of the ordinary is that the entire building is devoted to generating machinery, no boiler or producer room being necessary. When complete with four units, the station will total about 3.7 sq. ft. per rated kilowatt, a low figure for a plant of only 720 kw. capacity.

Generating units. Each of the two generating units at present installed consists of a 3-cylinder, vertical, single-acting gas engine, with cylinders, 18 in. in diameter by 22 in. stroke, running at 200 r. p. m., direct connected through a flexible spring coupling to a 180-kw., engine-type, 60-cyle, alternating-current generator. These units are of standard construction and include the very best features for obtaining satisfactory parallel operation, uniform speed under variable loads, continuity of operation, and low operating expense.

Auxiliaries. The auxiliaries include apparatus for supplying compressed air for starting the engines, 4-volt and 110-volt direct current for ignition purposes, 110-volt direct current for exciting the main generators, and water for cooling the engines.

Compressed air supply. The compressed air supply for starting the engines must be independent of the engines themselves, as it must be ready for use when the rest of the station is "dead." For this purpose, a small horizontal, single-acting gas engine is used, which is belted to a two-stage compressor; for breakdown purposes, a separate compressor is installed, belted to a countershaft which in turn can be driven by either of the main engines. The supply of air normally needed for starting the engines, is stored in two 16-in. cylindrical tanks at 200 lb. pressure. In addition, four more of these tanks, each controlled by its own valve, have been installed, which, as they are not to be drawn from except for emergency work, constitute a reserve for the engine-driven compressor. The six tanks total 102 cu. ft., or over ten times the cylinder displacement of one engine.

Ignition current. For initial ignition, there has been provided one set of primary "dry" batteries and one set of storage batteries, either of which is sufficient to operate the plant for some time. For ordinary use, however, a motor-generator set has been provided, taking current for its motor from 110-volt, direct-current, exciter bus-bars, and delivering from its shunt-wound generator, direct current of the same voltage. This supplies current to the ignition points which are operated in series with suitable resistance lamps. The storage batteries, however, are connected inside the lamps and work directly on the ignition points, thus allowing the batteries to "float" on the circuit, at all times fully charged and ready automatically to furnish the ignition current in case of accident to the motor-generator. Whenever necessary the 110-volt exciter circuit can be thrown directly on the same resistance lamps, but this has the drawback of permanently grounding the one side of the field winding of the alternating-current generators.

Excitation. The direct-current excitation for the main generators is provided by two 110-volt, compound-wound dynamos, either of which has sufficient capacity for both of the main units. These exciters are direct connected to induction motors which, in turn, are fed directly from either set of main switchboard bus-bars. These motor-generator sets are also provided with pulleys for belt connection to a countershaft which, in turn, can be run by either of the main engines through friction clutches. This clutch and belt device is occasionally a decided convenience in different ways, but its normal and important use is only for a few minutes, namely, after an accident has deadened the main alternating-current switchboard bus-bar. In this case the first main generator secures its excitation by means of an exciter set driven by its belt; the main generator is then switched on the bus-bars and supplies current to the induction motor of the other exciter set. Next, the exciters are paralleled, the load transferred to the second exciter, and finally the friction clutch driving the first exciter set is released.

Cooling water. The simplest method of cooling the cylinder jacket is, of course, to use fresh water directly from the city mains; this method, however, is rather expensive, and a circulating system has been installed which permits the use of a given quantity of city water over and over again until its temperature is too high. For this purpose, a two compartment concrete tank has been constructed on the roof of the building, provided with overflow and risers, connected with engines and city water piping. In these roof tanks a sufficient amount of surface cooling has been obtained to reduce the quantity of water required by the plant to about one-half of that needed without this circulating system, and this proportion will be still further reduced by a simple form of cooling tower now being constructed on the roof. For emergency use, it is proposed to employ well water, although impurities will not permit its steady use. The jackets do not work under full pressure head from the tanks, about 35 ft., but deliver into a supplementary tank located on the mezzanine floor of the engine room, giving about 5 ft. of pressure head on the engine jackets. This is sufficient to provide solid water at all points and to prevent air pockets. From this tank a centrifugal pump, driven by a 3 horse-power induction motor, delivers this water to the roof tanks.

Piping. The engine exhausts are carried out though the building walls with easy bends, and then rise 40 ft. to clear the roof. As water is used in the exhausts, these risers are drained near the engines. A simple steam exhaust head capping each riser completely deadens the exhausts, thus avoiding the difficulty sometimes experienced with gas plants located in residence territory.

The gas is delivered at the power house at about 15 lb. pressure, but this is reduced to 8 ounces before being metered. This pressure is further lowered to 2 ounces by the regulators furnished with each engine. Ample storage capacity in the shape of liberal piping, has been provided on both sides of the engine regulators to insure a moderately uniform flow of low pressure gas.

Parallel operation and regulation. As this is a 60-cycle, polyphase plant, carrying a mixed load of lights and motors, it is apparent that good voltage regulation is necessary and that satisfactory parallel operation is an indispensable feature. The very fact that the plant is able to give so good a quality of service is proof that the parallel operation bugaboo held over the gas engine for years, has been driven to cover especially with direct-connected 60-cycle generators. These units are paralleled in precisely the same manner as the ordinary steam unit, on an "opening throttle;" that is, the new unit is brought slowly up to synchronism with the one in service, and after the switches are closed, the throttle is spun open. There is an important advantage, however, over a steam engine of ordinary construction; namely, that the tension of the governor spring may be easily changed by hand while the engine is running, thus changing its speed and consequently its load also. As a matter of fact, instead of altering the governor spring, a pair of springs at the mixing valve working against the governor spring is adjusted, thus securing the same result. This adjustment, consisting simply of a pair of thumb screws, gives an opportunity to bring up the load on the new unit as slowly or as rapidly as desired, and to any point. Thus the fresh unit may be given more than its share of the load for a time to relieve the temperature of the other; or should an igniter on either engine give trouble, the load may be dropped to two-thirds rating without taking the unit out of service. This adjustment is also sometimes used to bring the engine into synchronism. The effect of a misfire in one of the cylinders is never noticeable on the line, except when the misfire continues for several cycles, which is rare. Naturally, it induces some little surging between the two machines, owing to the temporary disablement of a cylinder, but the shock is readily absorbed by the spring coupling and does not show the slightest tendency to throw the engine out of step. In general, the regulation from this plant is fully as good as could be expected from any steam plant, and is entirely due to the method of controlling the quantity of mixture by the governor, which is a fundamental feature of the 4-cycle gas engine.

Ignition. This is one of the most vital points in gas engine work and should receive careful attention from both the designing and operating engineer. There should be at least two separate sources of ignition current continuously available, which are provided for here by the small 110-volt shunt-wound generator and the set of 4-volt storage batteries, as before described. Only one case has occurred where an engine has been shut down from the loss of igniter current, and this was due to a ground in the conduit between igniter switchboard and engine. This occurred in spite of the precaution of running all wiring through loricated iron conduit. A few spare igniters are always kept on hand, and it is only a few minutes work to replace a disabled one. If, however, these are changed regularly and cleaned, as they should be, they give very little trouble. On these engines there is a device for changing the point of ignition while running. It is very necessary in gas engine work that ignition take place at the proper point, otherwise inefficient combustion shown by a badly distorted card, will result. But a good engineer can very readily determine whether the ignition is at the right point merely by the sound of the explosion. Should the gas change in quality for any reason, the ignition can be readily adjusted, as well as the mixture, in a few seconds, without in the least disturbing the running of the engine.

Starting. One very great advantage of gas engine work is the absence of standby losses after the engine is shut down, unlike the steam plant where there are condensation, radiation, and stack losses. The gas engine may stand for an hour or a month without incurring any losses whatsoever, and yet be in readiness for starting within a minute or two of the signal; but a steam engine must be warmed up and "turning over," previous to loading. In the Duquesne plant, compressed air is used for starting the engines. A supply several times greater than that actually required is aways kept stored in steel tanks at 150-lb. pressure. A single air valve controls each engine, and as soon as the air is turned on, the engine automatically comes up to speed, usually in about 45 seconds, so that the unit may be loaded within about one minute from the start, or at least two minutes. This is evidently a good feature in case of emergency spare units.

Station Efficiency. A power station is, in one sense, only a machine for converting the potential heat energy of fuel gas or coal into electrical energy. The efficiency of conversion depends almost entirely upon the type of plant. With steam engines, 4 pounds of coal per kilowatt-hour may fairly be assumed to be well above the average results obtained in lighting plants of less than 1,000 h.-p. capacity. Now 4 lbs. of bituminous coal of 14,000 B. t. u. per lb. (equal to 53.3 cu. ft. of natural gas of 1,050 B. t. u. per cu. ft.), is equivalent to a heat consumption of 56,000 B. t. u. per kilowatt-hour at the switchboard, or an absolute thermal efficiency (1 h. p. = 2,545 B. t. u.) of 6.1 per cent. between the coal pile and switchboard.

Curves were prepared to show the fuel consumption of the Duquesne Light Company's engines, and display the total hourly gas per engine, the gas per kilowatt-hour and the absolute thermal efficiency from gas to electricity. The "total gas" curve, from which the others were calculated, was determined by reducing the actual station records to the equivalent performance of a single engine, and was checked up by a number of readings taken at various loads. We will tabulate for illustration, the values for two different engine load-factors; namely, 40 and 80 per cent. These are extreme limits—a plant requiring five engines to carry its peak load should be able to operate at an average engine load-factor of 80 per cent. and a plant requiring two engines for its peak load would probably run with an average engine load-factor of 40 per cent.

Summarizing the tabulation, we find that natural gas of 1,050 B. t. u. per cu. ft. will give a kilowatt-hour on 21.2 cu. ft., with an average engine load-factor of 40 per cent.; if the engines can be run on an average load-factor of 80 per cent., the gas required will be only 15.2 cu. ft. per kilowatt-hour. These values can be reduced, for sake of illustration, to equivalent pounds of coal having 14,000 B. t. u. per pound; namely, 1.7 and 1.23 lb. per kilowatt-hour, respectively. If it is desired to compare these results with steam data expressed in terms of indicated horsepower these values will be approximately 0.96 and 0.78 lb., respectively.

Engine load-factor.	Cu. ft. gas per kw-hr.	B.t.u. per kw. hr.	Absolute efficiency of unit (gas to electricity).	Equivalent coal —B.t.u. basis— Lb. per kw-hr.	Lb. per i.h.p.-hr.
40%	21.2	22,200	15.35%	1.7	0.96
80%	15.2	16,000	21.4%	1.23	0.78

The comparison of the fuel consumption of the steam station described above, (operating on an equivalent of 53.3 cu. ft. of natural gas per kilowatt-hour) with the gas rate of a gas engine station which lies somewhere between the limits of 21.2 and 15.2 cu. ft., is a striking illustration of the great fuel economy of the gas engine, and is, in itself, a measure of the relative thermal efficiencies of the two methods of developing power from natural gas.

Cost of Power. All the various items entering into the cost of power are, at present, difficult to obtain in segregated form, but have been estimated as closely as possible from two different prices of gas.

		25c. Gas.		15c. Gas.
		% of total.	Cents per kw-hr.	Cents per kw-hr.
Fuel gas		47.6	.440	.264
Wages		28.3	.260	.260
Supplies—				
Oil waste	11.3			
Water	9.0			
		20.3	.187	.187
Repairs		3.8	.026	.026
Totals		100.	.913	.737

This estimate, based upon the present load-factor and the complete plant, shows a total operating cost well under 1c. per kilowatt-hour for the highest priced gas, and 0.75c. for the lowest.

In the near future, this will be somewhat lowered by a reduction in the cost of water due to the cooling system mentioned above. Such a low cost shows the possibility of developing a large daylight power load, which feature appeals strongly to electric light managers.

It is difficult to compare these fuel costs per kilowatt-hour with those of ordinary steam plants, as so much depends upon the character of their service and apparatus, but a large number of electric light plants under 1,000 horsepower will have a fuel consumption varying between 4 lb. and 8 lb. of coal. It is also fair to assume that their expenses, outside of the fuel item, will not differ materially from those given above (in a great many cases their wage item will materially exceed 0.26 per kilowatt-hour).

On this basis, then, natural gas at 25 cents per 1,000 cu. ft. is competitive with coal at $2.20 per ton, on a consumption of 4 lb. per kilowatt-hour, also with $1.10 coal, on the basis of 8 lb. per kilowatt-hour. Similarly, 15c. gas is competitive with coal at $1.32 per ton with a coal consumption of 4 lbs. per kilowatt-hour and with coal at 66c. a ton on a consumption of 8 lb. per kilowatt-hour.

Conclusion. It is well to keep clearly in mind that a gas power station can utilize to better advantage a larger number of generating units than can a steam station. The reason for this is that the gas engines are practically as efficient in small as in large sizes, and that the cost per kilowatt, and floor space occupied per kilowatt of rating, is likewise nearly uniform. Consequently, it is better to split up the station capacity as much as possible, thereby enabling the operator to fit his units into the load curve and obtain a better efficiency for the station. The available space power will also be better distributed, and this multiplicity of units more readily provides for the possibility of losing an igniter. With one unit running, the disablement of one cylinder amounts to 33 per cent. of the rated capacity; with two units running this deficiency amounts to 16.6 per cent.; with three units, the deficiency is reduced to a little over 11 per cent. of the total capacity in operation. With four units running, the deficiency is but 8 per cent., which can be readily taken care of by the overload capacity of the remaining cylinders.

General experience with the Duquesne Light Company's plant thus far indicates that good service, combined with low operating costs, may be expected if proper attention is given to keeping the equipment in good working order. It is true that inexperienced or careless men cannot get the best results from a gas equipment, but with an experienced, active engineer in charge, the equipment is as trustworthy as a steam plant.

Mr. J. R. Bibbins contributed the following discussion of the paper:

One of the most important is the question of relative spare capacity. In planning a new station, this question arises right at the outset after the problematical load curve has been determined upon—how many, and what size of units will be installed. Although one or two units yield the simplest form of plant, when one considers the average running efficiency the unit will give under the given load-factor it is a different matter.

In a recent study of this point, a 1,000-kilowatt maximum load curve was assumed with 1, 2, 3, 4 and 5 service units and a single spare unit. By "blocking in" the engine curves corresponding to the actual capacity in service at a given time, the average load on the engine was obtained in per cent. of its rating, this being obtained by integrating both load and engine curves. Thus the relative heat consumption under average running conditions was obtained. For this particular load curve the first three unit combinations worked out best in horizontal units, the last two in vertical. For five units this condition works out to an average heat consumption of less than one-half that required by a single unit; in other words, an efficiency of twice as great. As to the cost of spare capacity for the single-unit plant, we must provide a spare unit equal to the running capacity—100 per cent., two units, 50 per cent., etc., down to 20 per cent. for five units.

It may be contended that the relative heat consumption and the cost of spare capacity are only small factors in the final solution of the problem, but this is not the case. The modern gas engine requires, in the larger sizes, a type of construction which does not permit of very great reduction in cost over smaller sizes which embody the vertical self-contained construction. It thus develops that the price of a large gas-engine unit is very little lower than that of a medium-sized unit. Again, we find that the heat efficiency of the large unit is but very little higher than that of the smaller sizes, due largely to the inherent properties of the combustion cycle rather than to any precise refinement in design or construction which so clearly disclose the character of steam engine construction. Analyzing the labor cost in the station, we find that with the compact, self-contained, vertical unit, this item is very nearly the same as for equivalent horizontal capacity. Thus the problem practically reduces itself to that of relative operating efficiency and investment in spare units with the result above noted.

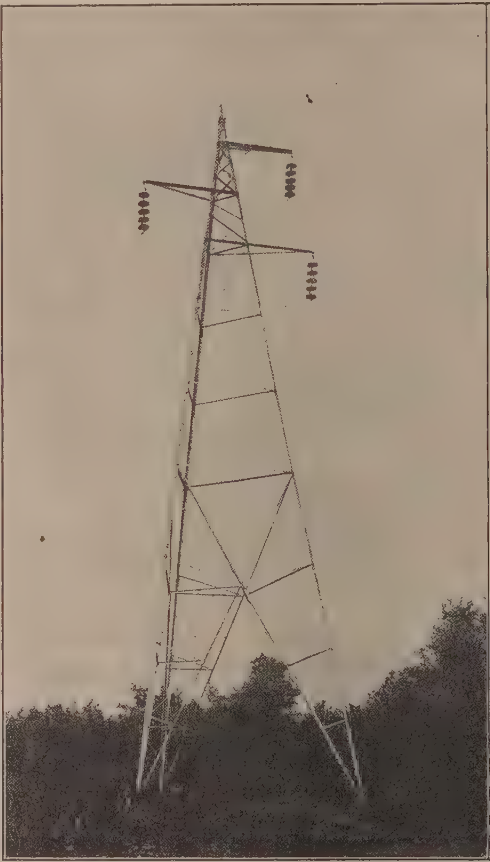
On the question of spare units we may assume as a possible contingency that an igniter will give trouble at some time. This throws a certain part of the engine out of service, but does not necessarily disable it. With one unit running, the loss of an igniter would cause 25 per cent. loss of power, and with five units, 6.6 per cent., but on the standard overload ratings each engine cylinder is capable of delivering 10 per cent. overload continuously. This overload capacity thus comes to the rescue of the disabled igniter. With two running units in the plant, we will barely be able to carry full load; with three units the extra capacity will tide us over; with five units the plant will develop 2.7 per cent. in excess of the rating in spite of the disabled igniter.

An overload capacity of 10 per cent. seems small compared with the similar capacity of a steam engine or steam turbine unit. While a steam unit gives its best economy at full load or under, the economy of the gas engine increases up to the maximum load, which makes it desirable to rate the engines and operate them as close to maximum as is permissible, and while the gas engine has a decided advantage for steady central station service, it is somewhat at a disadvantage on rapidly fluctuating loads. This, howevery, may be overcome by the use of a storage battery. A system has recently been devised by which the generator load may be held practically constant while the entire fluctuating load may be taken up by the battery. This is accomplished by a load regulator, a simple instrument of the relay type, installed on the switchboard and operating in connection with the booster. In a recent test with this system, the external load was instantly varied through a range equivalent to 300 per cent. of the generator capacity, yet these variations were entirely absorbed by the battery, and the generator kept within a few per cent. of its rating, irrespective of the suddenness or the violence of the fluctuations. This instrument is particularly useful in gas engine work as it permits full loading of the unit with impunity whereas it might be necessary to reduce the average loading to one-third of the rating in order to take care of the fluctuations.

Denatured Alcohol to the amount of 1,744,272 gal. was produced in the United States during the first six months of this year. The free alcohol law took effect Jan. 1, 1907.

Three Low-Head Hydro-Electric Developments in Michigan.—Part II.

Big Rapids Dam Development.—The Big Rapids development, 18 miles up the river from Croton, is at a point where the river valley is 800 ft. wide and 40 to 50 ft. deep. The dam renders available a head of 40 ft., which is utilized by equipment having a total capacity of 6,000 h.-p. The dam consists of an earth embankment, with a concrete waste-gate section built in it, toward one end, and a power house also built in it across the original channel of the river, which was at one side of the valley. The whole site is underlaid by hardpan that is covered with coarse sand and gravel. At the power house, in the channel of the river, this overlying sand and gravel was 20 to 50 ft. deep, but graded off in depth toward both sides of the valley, the flood-gate section being built directly on the hardpan. A continuous line of steel sheet piling, extending entirely across the valley under the site of the dam, was driven into the hardpan far enough to form a complete cut-off wall in the sand and gravel, and is carried into the sides of the valley to prevent leakage around the ends of it. The embankment contains a 10-in. reinforced-concrete core wall, built on this row of steel piling; the latter is also at the upstream limits of the concrete in the gate section and the power house. Some of this steel piling was driven to a depth of as much as 56 ft., the long pieces being spliced. The core wall, like the one in the embankment of the Croton dam, is located so its top is at the intersection of the surface of the water in the pond and the slope of the embankment. The power house is carried entirely by wooden piles driven down to the hardpan. The substructure of the power house is also enclosed on all four sides by sheet piling, driven to the hardpan, the row of steel piling forming the upstream side of this enclosure and wooden sheet piling the other three sides. The



Tower of 100,000-Volt Transmission Line.

Strain Insulators at a Change in Grade.

wooden piling consists of 6 x 8-in. and 7 x 9-in. tongue and grooved timbers, in 12 to 26-ft. lengths.

The embankments of the dam were made by teams and scrapers, most of the material being obtained from a borrow pit on the power house side of the valley. This material is largely all sand and gravel similar to that used in the Croton dam. The embankments have slopes of a 2 to 1 on the downstream side and of 3 to 1 or flatter on the upstream side.

Waste-Gate Section.—The waste-gate section, with a total width of 150 ft., is arranged practically the same as the waste-gate section of the Croton dam. It contains six Tainter gates, each 20 ft. wide and 12 ft. high, three of which are on each side of a log sluice, 6 ft. wide. These gates are raised and lowered by motor-driven hoisting crabs, the same as those described in connection with the Croton development. The spillway on which the gates seat when closed is a hollow reinforced-concrete dam, of the same general design as the one at Croton, the water falling from it into a tumble bay formed by an overflow weir, 69.5 ft. downstream from the gates. This tumble bay is divided into two parts by the walls forming the sides of the log sluice. Each of these parts is arranged with outlets so it can be drained when the three gates discharging into it are closed. The retaining walls on both sides of the waste-gate section are extended downstream for 240 ft. from the gates, forming a waste-way channel, 180 ft. wide. A second row of steel sheet piling is placed across this channel just below the tumble bay, and for 50 ft. from the latter the bottom of the channel is protected by rock-filled timber cribs, with the filling in these cribs grouted. The bottom of the remainder of the channel enclosed by the retaining walls is protected by a concrete lining.

Power House.—The concrete substructure of the power house is 50 x 95 ft. in plan, with its center line normal to the axis of the dam, and has concrete wing walls extending up and downstream from both ends of it. The power house proper is a brick structure 40 x 50 ft. in plan on the downstream end of this substructure. It contains two 3-phase 30-cycle 6,600-volt revolving field Westinghouse generators, each direct-connected to two pairs of 45-in. horizontal center-discharge Samson turbines in one of two open steel-plate penstocks of the Rickey type, which are erected over the upstream end of the substructure. The units operate at 225 r. p. m., each generator being capable of developing the full 3,000-h.-p. capacity of the four turbines which drive it. A 30-kw. direct-current motor, direct-connected to the shaft of the main unit, furnishes excitation current for each generator. A Tirrill regulator is provided to control the voltage of each generator. The operation of each set of two pairs of turbines is controlled by a Type N Lombard governor, belted to the main shaft of the unit.

The 6,600-volt current delivered by the generator is stepped up to 72,000 volts for transmission to Muskegon and Grand Rapids by three oil-insulated water-cooled transformers in a separate 28 x 40-ft. fireproof building on the side of the valley, about 50 ft. from the power house. The busbars in this building are in separate fireproof compartments and all connections to them are provided with special hand-operated oil switches, in fireproof cells.

When the development was completed the turbine plant was tested in place under the supervision of Professor Gardner S. Williams, of the University of Michigan. The power output of the generators was measured electrically, while the water was measured over a 112-ft. steel-crest weir, according to Francis' directions and formula. The testing of the electric equipment was in charge of the Electrical Testing Laboratories of New York. The results obtained agreed essentially with the turbine makers guarantees.

Two Views of the Big Rapids Development.

Inclined racks placed across the open upstream end of each of the penstocks intercept such floating debris that passes under a log boom in the pond which is arranged to direct the debris through the log sluice in the waste-gate section. These racks consist of ¼ x 3-in. bars bolted together in sections and carried by a frame of structural steel shapes. Stop-log grooves are also provided in the sides of the penstocks, in front of the racks, so the openings may either one be closed. These stop-logs are handled by one of the hoisting crabs used in operating the Tainter gates, the track for the crabs being extended from the waste-gate section into the house over the penstocks. This house is a frame building with sheet iron sides and roof, which is provided to protect the men clearing the racks, or working on the stop-logs.

A draft tube for each pair of turbines is formed in the concrete base of the substructure, the two draft tubes of each two pair of turbines discharging into one of the two parts in which the tail race is divided by a longitudinal wall under the building. The draft tubes are lined with steel plates and are designed to deliver the water to the tail race quietly. The bottom of the tail race is protected by a concrete apron that extends 20 ft. downstream from the substructure, a row of wooden sheet piling being driven under the end of this apron and connected with the rows of piling which were along the sides of the latter.

Construction of Big Rapids Dam.—The Big Rapids dam was also built on force account by the Grand Rapids-Muskegon Power Co. under the direction of the same engineers mentioned in connection with the Croton project, except that Mr. N. F. Johnson was superintendent in charge. The construction plant was assembled during the winter of 1904-05, and active work was begun March 1, 1905, the generators being placed in operation on March 15, 1907. The construction plant was essentially similar to that used at the Croton dam, except that it was all steam-driven; the construction methods employed were also very similar to those followed on that work. The river was allowed to follow its channel until the work had been carried up to it on both sides, when it was diverted through temporary openings in the waste-gate section until the power house was finished. The water was then turned through the penstock and the temporary openings in the waste-gate section were closed.

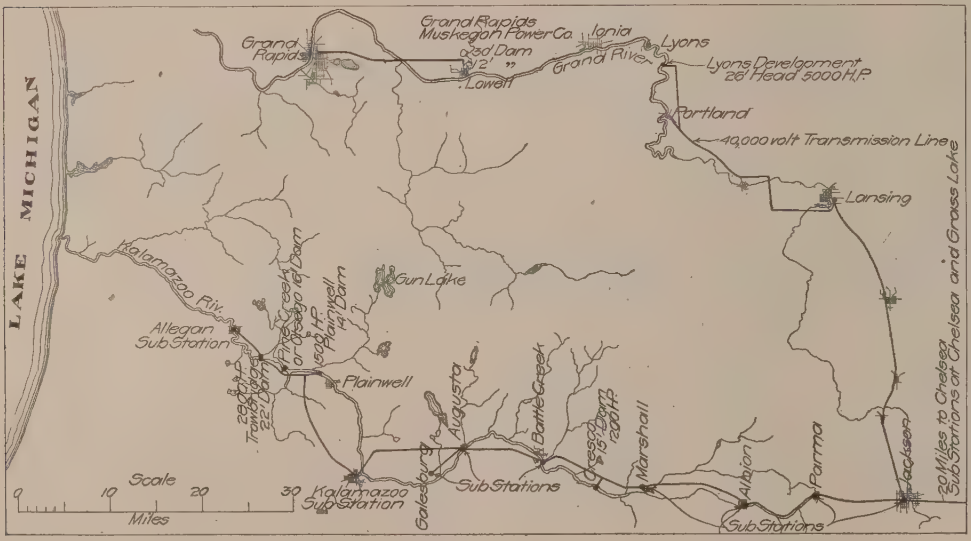
This dam required 18,000 cu. yd. of concrete, in which natural bank gravel, obtained immediately at the site, was used. The plant for handling the gravel and concrete was very similar to the one at Croton which has been described, the gravel being delivered in scrapers directly from the pit to charging hoppers at the mixing plant. The cement used in the concrete was shipped in cloth sacks in January and February and was hauled 1½ miles from the railroad in sleighs on the snow. It was stored in 40 x 90-ft. sheds, with a one-third pitch batten roof, covered with tar paper, in the usual manner of lumber camp construction. The floor of this shed consisted of two courses of 6-in. poles, laid on the ground, the second course being at right angles to the first. These poles were covered with about one foot of loose straw, on which was placed a single layer of tarred roofing felt; the sacks were then piled five high on end on this felt. No cement was lost by caking, and in fact, the only cement that showed effects of dampness was that on top, which gathered some moisture from the air, and caked in places to a depth of about ½ in. If tarred paper had been put over the tops of the sacks, it is believed that even this small amount of caking would probably not have occurred.

Transmission Lines.—When the Big Rapids development was made a transmission line, carried by poles, was built from the dam to a switch station at Casnovia, 33 miles from the dam; one branch of the line was extended from this station to Grand Rapids, 21 miles, and a second branch to Muskegon, 25 miles. This line passes close to the Croton development, the generating equipment of which is connected with it. The line has been operated satisfactorily at 66,000 volts and will be operated at 72,000 volts in the future. Power is delivered to three sub-stations, one in Muskegon, one near Grand Rapids and one in that city.

Michigan and Idaho cedar and Southern cypress poles, 45 to 60 ft. long and placed 40 to the mile, carry the three conductors of the transmission line, which are No. 2 solid copper wire. These wires are carried by Locke insulators, 14 in. in diameter and 18 in. high, at the corners of a 72-in. triangle. These insulators are mounted on two cross arms carried by the poles, wooden pins being used on straight-line work, and iron pins at angles; all pins are 18 in. long and are 2 in. in diameter at the shoulder. A No. 6 iron wire, grounded at every fifth pole for lightning protection, is carried by the upper cross arm on the poles.

A second transmission line, 35 miles long, is being built from Croton directly to a sub-station in Grand Rapids and will be operated at 100,000 volts. This line will be entirely distinct and separate from the original one, so a duplicate line between Croton and Grand Rapids will be provided when it is completed. Interruptions to the transmission system between these two points, due to the local thunderstorms, which occur in this section, will thus be avoided largely, since a disturbance affecting one line would very probably not affect the other.

General View of the Lyons Development from the Downstream Side.



Map Showing Plants and Transmission Lines of the Commonwealth Power Co.

The new line is carried by triangular steel towers, 40 to 60 ft. in height, which were built by the Aermotor Co. These towers are placed about 500 ft. apart, and have each leg anchored to a 3-in. steel angle, 7 ft. 10 in. long, buried in ground. The angles are incased in concrete to prevent the corrosion that would probably take place rapidly in the porous sandy soil. These angles are each extended about 10 in. below the bottom of the concrete in which they are encased, to provide a ground for the transmission line. The three conductors are equivalent to No. 2 wire, being stranded copper wire with a hemp center. They are carried by suspension insulators on cantilever arms at the top of the tower. These insulators each consist of five umbrella-shape porcelain sections, 10 in. in diameter, having two interlinked semi-circular holes, through which tie wires that attach the sections together are passed. These holes are so arranged that the tie wires which pass through them exert a compression strain on the porcelain. In case a section breaks, the tie wires remain intermeshed, and as the sections are in series, and have a factor of safety, the remaining sections prevent a ground. A strain insulator, consisting of disks with grooved flanges, the mechanical and electrical features of which are essentially the same as in the umbrella-shape sections, is used at turns and at various intervals to support and anchor the line on curves and in similar places.

The angles to which the legs of the towers are anchored were encased in concrete at the mixing plant at Croton, and were distributed along the line by railroad shipments and in wagons, after the concrete had set, each complete anchor weighing about 275 lb. A set of removable forms, built for casting the concrete around the angles, proved very satisfactory. The cross section of this enclosing concrete is an ellipse with 4½ and 6-in. axes. One 3-in. 4-lb. channel and several short reinforcing rods, fastened horizontally near the bottom of each main angle as anchors, are also enclosed in a disk of concrete, 5 in. thick and 1.5 ft. in diameter, which is cast with the column enclosing the main upright angle. The form for the concrete columns consists of No. 16 black sheet iron bent to the shape of the column, and divided on the long axis of the cross-section of the column into two parts; these parts overlap at the joints and are held together by four hinged clamps of ¼ x ½-in. band iron. The form for the disk of concrete at the base is also made of No. 16 black iron, and has a collar at the center which slips into the column form to a tight fit. These forms are set up in groups, with the base down, on a platform close to the mixer so they can be filled with concrete readily. This work is thus handled quite economically, while it would practically be impossible to make provisions for mixing the concrete and placing it around the anchors at each tower.

The Lyons Development.—The Commonwealth Power Co. of Jackson, Mich., by which the development on the Grand River near Lyons was recently completed, also owns and operates six hydro-electric developments on the Kalamazoo River. The location of these various developments and of the transmission lines extending to the cities served by them are shown in an accompanying map. All of the developments supply power for public service systems in Lansing, Jackson, Battle Creek, Kalamazoo and Allegan and intermediate towns. Interurban electric railways extending from Jackson to Kalamazoo, Jackson to Lansing, Lansing to St. Johns, the local street car lines in Jackson and Lansing, and that part of the Detroit United Rys., from Jackson to Ann Arbor, are also supplied with power from the generating stations of this company.

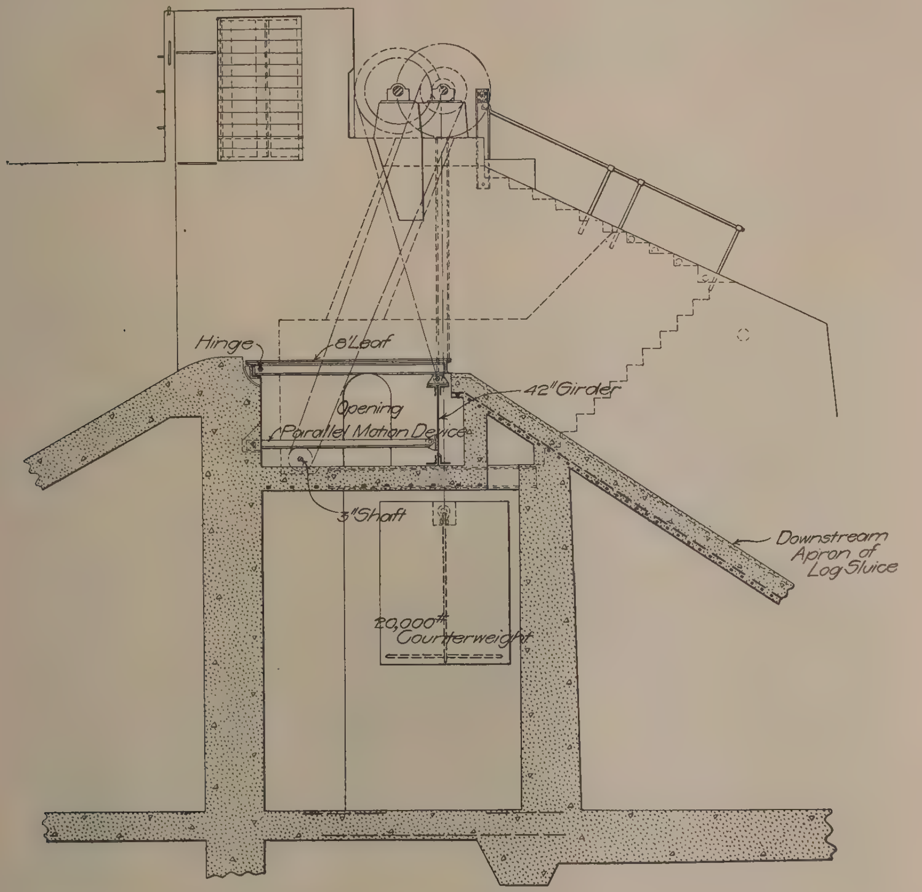
The Lyons development is a few miles above the low flat stretch of the river which extends from Ionia to Lake Michigan. The catchment area of 1,750 square miles above the development is largely clay soil; hence, severe floods occur, while during periods of drought, the minimum flow drops to about 200 cu. ft. per second. The dam develops a head of 26 ft., and is built entirely of reinforced concrete, excepting a short embankment at both ends. In order to provide a passage for flood water, without materially raising the surface of the 1,775-acre pond, ten steel Tainter gates, each 20 ft. wide and 13 ft. high, are provided in a waste-gate section at one end of the dam. Five of these gates are on each side of a sluiceway opening, 60 ft. wide, in which a movable crest, or bear-trap dam of that width is operated. The arrangement and design of the Tainter gates are the same as for those of the Croton development. These gates are also raised and lowered by worm-geared, hand or motor-operated portable hoists of the same type as those used at Croton.

The details of the design and construction of the 60-ft. movable-crest dam in this waste-gate section are similar to those of the movable-crest dam at Croton. The Lyons dam has a movable leaf, 8 ft. wide and 60 ft. long, which turns on a shaft in a hinge along its upstream edge, thus permitting the downstream edge to be raised and lowered through a vertical travel of 5 ft. The leaf is counterbalanced by two 20,000-lb. weights, one of which is placed in a compartment in the dam beyond each end of the movable crest. The leaf is raised and lowered by two series of worm and spur gears, each driven by a 10-h.-p. motor and operating in connection with the counterweights.

A built-up steel girder, 42 in. high, extends the full length of the 8-ft. leaf, and is suspended from the front edge of the latter by hinged joints. These joints permit the girder to remain in a vertical plane at any position of the leaf, the verticality being maintained by a parallel-motion arrangement. When the leaf is at its lowest position with its upper surface horizontal, its weight and the load on it are carried by the girder, the latter resting on the bottom of the depression in which the movable crest is set. When the front edge of the leaf is raised to the full height of its travel, it is also carried by the girder, which is blocked up on jack screws set on steel posts projecting above the bottom of the depression under the crest.

The 60-ft. opening controlled by the movable crest is spanned by a two-leaf trunnion footbridge. Each of the leaves of this bridge can be turned sufficiently on a trunnion, on the guyed steel tower that carries it, so the 60-ft. opening is practically unobstructed when the two are open. The leaves are raised by cables on hand-operated worm winches.

Power House.—The power house adjoins one end of the waste-gate section and is L-shape in plan. The construction and arrangement of the Lyons power house is very much the same as in the case of the power house at Croton. The long axis of the power house proper is normal to the axis of the dam, with a row of four penstocks forming the stem of the ell. It contains a single 3-phase 30-cycle 6,600-volt revolving-field 2,500-kw. General Electric generator, direct-connected to four pairs of 50-in. center-discharge Samson turbines in the penstocks by a shaft 138 ft. long, that is normal to the direction of flow through the dam. The whole arrangement of this equipment, including most of the details, is very similar to that of the equipment in the power house at Croton.

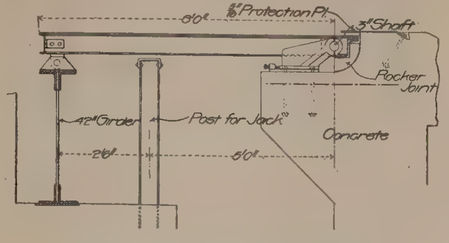


General Arrangement of Movable Crest Dam at Lyons.

Construction of Lyons Development.—The construction of the dam at Lyons was started in March, 1906, and the equipment was placed in service in March, 1907. The foundation throughout is a hard clay at a depth of from 6 to 15 ft. below the surface of the river, so no piles or sheet piling was used under the dam, although some of the wing walls at the ends of the dam, and the dividing wall between the tail race and the waste-way channel from the Tainter gates are on piling.

A Close View of the Movable Crest Dam at Lyons.

Power for all of the construction plant used at the Lyons dam, except one steam shovel, was furnished by a 500-volt direct-current generator supplied with steam from a 200-h.-p. plant. Coal for this plant was hauled three miles from the cars by teams. The steam shovel was used in making the excavation required to provide a waste-way channel for the flood-gate section. The material removed from this excavation was handled in 4-yd. dump cars which were hauled out of the pit on an incline leading through the dam by means of a motor-driven hoist. Motor-driven hoists were also used on the derricks. The concrete mixing plant at this dam was located at the land end of the waste-gate section, and was quite similar to the one used in constructing the dam at Croton; the methods for handling concrete from this plant to various parts of the work were also the same as used in building that dam.



Detail of Movable Crest Dam.

Table 2. Cost of Placing Material in Embankment Section of Lyons Dam.

Labor and Coal Cost.

Setting pumping plant, labor on house for same, placing pipe, etc.	$531.38
Labor at power house	577.20
Labor at pump house	486.60
Sluicing labor, building flumes and trestle	3,117.50
675 tons of coal	1,687.50
	$6,400.18

Earth moved from pit, 23,400 cu. yd., = $0.273 per cu. yd. for labor and coal.

Cost of Sluicing Plant at Lyons Dam.

2 6-in. rotary fire pumps, new 1 5-in. rotary fire pump, second-hand	$1,300.00
Pipe fittings, trough, etc.	1,200.00
Lumber and sundries	500.00
Total first cost	$3,000.00
Less salvage, on sale of plant	1,800.00
Cost to be charged to this work	$1,200.00

$1,200 divided by 23,400 = $0.0513, cost of plant per cubic yard of earth moved.

Labor cost per cubic yard of earth moved	$0.273
Plant cost per cubic yard of earth moved	$0.0513
Total cost per cubic yard of earth moved	$0.3243

Ran 45 24-hr. days, Dec. 5, 1906, to Feb. 20, 1907.

The power house proper was built on the edge of the river channel, the waste-gate section extending across the flats to the low bluff of the river back of it; and the penstocks, 100 ft. out into the original channel of the river, on the other side. Beyond the penstocks an earth embankment, about 150 ft. long, extends to the high clay bluff that forms the river bank on that side. This embankment contains some 23,000 cu. yd. of material that was placed during December, 1906, and January, 1907, with a hydraulic sluicing plant.

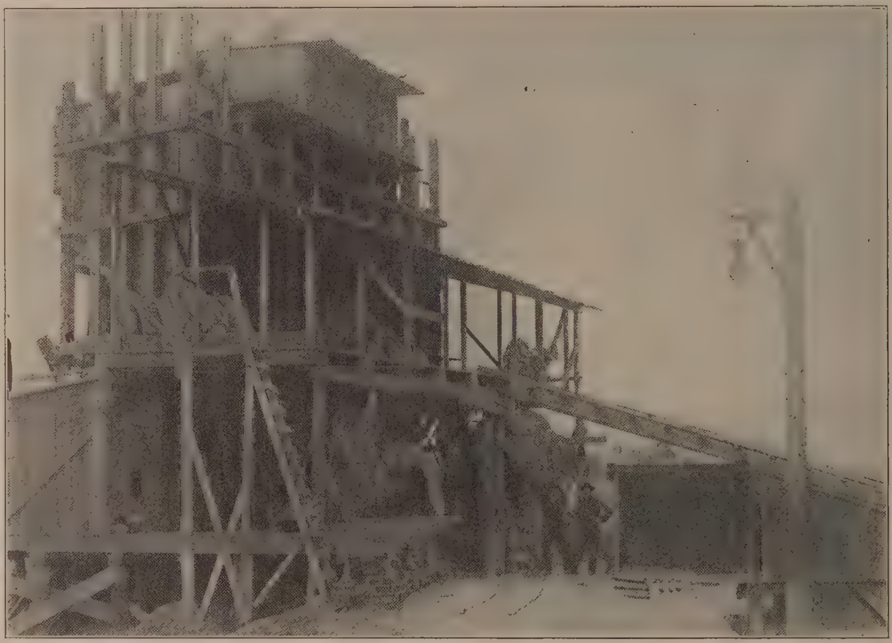
Hydraulic Sluicing at Lyons Dam.—The operation of a hydraulic sluicing plant for making an embankment during the winter months in this climate was contemplated with much anxiety. As suitable filling material was difficult to obtain otherwise, without a long haul, and as the pumps required were on hand, the plant was set up and started late in November, 1906. The bank of the river from which the material for the embankment was obtained is a clay bluff, about 70 ft. high, capped with about 10 ft. of sand and gravel. The clay was so tough and compact as to be very expensive to handle by ordinary sluicing means, so the fill was made almost entirely from the sand and gravel overlying it. As the bluff did not have a very steep slope, several expensive trestles were necessary to carry the flumes in which the material was handled from the face of the excavation to the fill. These trestles and the difficulties from ice made the cost of the fill much above that usual for such work, when more favorably situated and carried on in warmer weather. The sluicing plant was stopped when the temperature approached zero, with the result that when it was started again the face of the bluff, being saturated with water, had frozen to a depth of several feet meanwhile and had to be blasted. Even at the cost of 33 cents per cubic yard for the material moved out of the sluicing pit and deposited in the embankment under these most unfavorable conditions, as shown in Table 2, it is to be doubted whether any other method of moving material into the fill would have been less expensive. At any rate, the sluicing plant was certainly a valuable aid in making a fill so the river could be quickly closed, and also at times of flood during the two months it was in intermittent operation, in raising the cofferdams used in the construction of the penstocks.

The general offices of the Grand Rapids-Muskegon Power Co. are at Grand Rapids, Mich. Mr. W. G. Fargo is hydraulic engineer for the company and was supervising engineer during the construction of the Big Rapids and Croton developments. Mr. J. B. Foote is electrical engineer for the company and Mr. Anthony J. Bemis was manager during 1905 and 1906. Mr. J. B. Foote is general superintendent of the Commonwealth Power Co., which has its general offices at Jackson, Mich. Mr. W. G. Fargo was consulting hydraulic and supervising engineer to the company during the design and construction of the development at Lyons.

The Benguella Railway, Africa.

The Benguella Ry. is one of the most interesting undertakings of its sort now under construction in Africa. It starts from Lobito Bay in Portuguese Angola and follows the coast to Benguella, whence it runs inland to Katanga in Belgian Congo. The total length is about 800 miles; 50 miles are in operation, 200 miles under construction, and surveys and plans are completed for another 250 miles. Lobito Bay has an excellent harbor which is now being improved so that the large steamers of the Union Castle, Elder, Dempster and other lines can be accommodated. Katanga is the center of a remarkable mineral district. About 8,000 men are now employed on construction, and it is expected that 4,000 more will be engaged very soon. At one point on the line it is necessary to use a rack railway for about 1¼ miles, and there is some rocky country where heavy earthwork is necessary. These are about all the difficulties encountered except one very dry territory, where it has been found advisable to use camels for transport during construction. The work is being done by Griffiths & Co., with Sir Douglas Fox & Partners and Sir Charles Metcalfe as consulting engineers.

The Total Production of Coal throughout the world in 1906 has been estimated at 1,106,479,000 short tons, of which the United States produced 414,157,000 tons. In 1906 the United States produced 43.7 per cent. more coal than Great Britain and 85 per cent. more than Germany.



Concrete Plant at Hydro-Electric Development at Lyons, Mich.

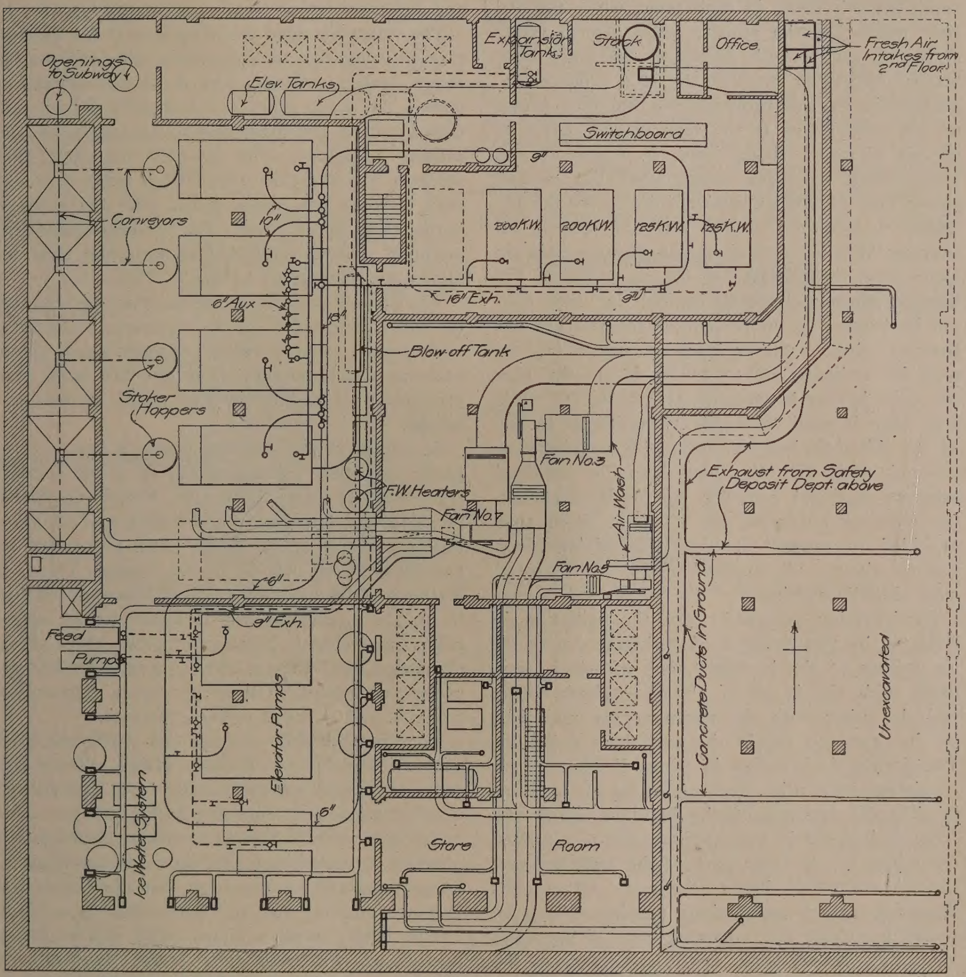
Heating and Ventilating the Commercial National Bank Building, Chicago—Part I.

The new Commercial National Bank building is an eighteen-story steel frame office building that has recently been completed on the northeast corner of Adams and Clark Sts., Chicago, Ill., fronting 181 ft. on Adams St., and 190 ft. on Clark St. It is a structure of large size, with a basement and sub-basement and rises 300 ft. above the level of the sidewalk. Its exterior has been treated in granite and terra cotta throughout, while the interior is elegantly finished in mahogany and white marble. The structure is supported on caisson foundations, of which there are 82, ranging from 6 ft. in diameter to 10½ ft., that extend down about 110 ft. to bed rock. The greater part of the second and third stories and the basement are devoted to the needs of the Commercial National Bank, while the upper floors from the fourth to the eighteenth inclusive, are devoted to rented offices. A feature of the interior arrangement is the concentration of all the toilet rooms for the rented office floors, together with a barber shop and a ladies' retiring room, on the eleventh floor. The building has a floor space on each of its three lower floors of over 32,000 sq. ft., and on each of the upper floors of about 25,000 sq. ft., owing to a light and ventilation court rising from the third floor level to the top, which makes a total floor area of over 470,000 sq. ft., exclusive of the basement and sub-basement.

The extensive mechanical plant required for the operation of the building service is housed in the sub-basement and a portion of the basement, the greater part of the former and nearly half of the latter floor being thus utilized. The sub-surface floors have additional space excavated underneath the sidewalk areas, the basement 190 x 195 ft. in size, having a total floor area of over 37,000 sq. ft., while the sub-basement, which was excavated only to within about 60 ft. of the easterly wall, owing to difficulties encountered with the foundations of the Marquette Building adjoining, has a floor area of nearly 27,000 sq. ft. Each of these floors has a ceiling head-room of only about 13 ft., on account of which the boiler room, 72 x 98 ft. in size, in the northwest corner on the Clark St. side, and the engine room, 58 x 85 ft. in size, adjoining at the rear, were carried up from the sub-basement through the basement floor level in order to secure the needed additional head-room to accommodate overhead piping and to facilitate the handling of the machinery. The remaining portions of the sub-basement are devoted to the hydraulic elevator equipment, ventilating apparatus, other auxiliary machinery, a machine shop and storeroom and locker rooms for the employees of the building, while on the basement level there is, in addition to the boiler and engine room, considerable additional ventilating equipment.

The power plant of the building has been installed with a complete equipment for all classes of service, embracing 4 boilers, aggregating 1,400 h.-p. in capacity, for steam generation; an electrical generating equipment of 650 kw. capacity, an extensive hydraulic elevator plant, refrigerating machinery and pumps. The exhaust steam from the plant is utilized for the heating of the building. The boilers are of the Sederholm type of fire-tube boilers, built by Chalmers & Williams, and are installed in four 350-h.-p. units, arranged in separate settings on the east side of the boiler-room with space reserved for an additional future unit to be installed at the south end if required. The boiler units are brick set, the settings being covered with vitrified asbestos, and each is equipped with a Greene chain grate stoker. The arrangement of units is such that there is a 10 to 12-ft. space at the rear of the settings for blow-off piping, steam mains and smoke breechings, a 16-ft. firing floor in front of the stokers and 7½-ft. spaces between settings as necessitated by the arrangement of building columns. The front portion of the boiler-room is occupied to a width of 16 ft. by a coal storage bunker, 88 ft. in length, which has a capacity of over 700 tons of coal. Arrangement has been made for delivering coal to the plant by way of the Chicago freight subway lines, a branch of which has been constructed from Clark St., underneath the boiler-room; from cars on the subway line the coal is dumped into a receiving hopper from which a bucket traveling conveyor, built by the Link Belt Machine Co., Chicago, elevates the coal to the storage bunker. The coal is also mechanically handled from the bunker to the stoker hoppers by means of screw conveyors which transfer it into small circular hoppers above the stokers, fitted with adjustable spouts. The ashes are dumped from the furnaces into a pit below the boilers which has connection with a tunnel leading to the branch track from the subway line, through which the ashes are delivered by special ash cars to cars of the tunnel line for removal. The products of combustion are removed from the boilers by a steel stack, 90 in. in diameter, that rises to the roof, a height of 350 ft. above the grates. Connection is made from the settings to the stack through a rectangular iron breeching carried on the ceiling at the rear of the boilers and both the breeching and the stack are lined throughout, the stack with a 2-in. lining of vitrified asbestos, supplied by the Chicago Fireproof Covering Co.

As the exhaust from the steam using machinery of the power plant is used largely for the heating of the building, the feed water supply is principally of condensation return from the heating system, with make-up from the city water mains as required. The condensation return lines from the heating apparatus and low pressure apparatus connect at the rear of the boiler-room into an 8-in. valved header, which in turn makes connection to each of the two open feed-water heaters which are provided for preheating of the boiler feed before delivery to the boilers. These heaters are Webster Star vacuum heaters and purifiers, each having a capacity of filtering and heating 30,000 lb. of water per hour from 45° to 210° Fahr. These heaters have connections to the 12-in. exhaust main extending over them from the pumproom to the expansion tank at the rear of the engine-room. The boilers are fed by an equipment of two Worthington duplex pumps of the outside center packed plunger type, which are brass fitted throughout for the handling of hot water, and each is designed for a capacity of 30,000 lb. of water per hour with a piston speed of not over 25 ft. per minute, so that each pump is capable of feeding the entire boiler equipment under normal conditions of service. They are located at the north end of the pumproom and have connection to suction and delivery lines in duplicate, the mains being so valved that one pump may deliver from the feed-water heaters to one or more boilers, and the other from the surge tank to the other boilers, or in any other combination desired. One of the feed mains, known as the hot-water feed line, is fitted with a Worthington meter by means of which the feed delivery to the boilers is measured. The blow-off system of the plant consists of a 4-in. blow-off header at the rear of the settings with 3-in. connections to the mud drums of each boiler unit and a 6-in. delivery connection into a large blow-off tank in a pit at the rear of the settings; this blow-off tank is a cylindrical steel tank 3 ft. in diameter by 13 ft. long, and has a 6-in. overflow to the sewer, so located as to maintain in the tank sufficient water for partially cooling the blow-off discharge as received. The vapor from the hot discharge is removed by an 8-in. vapor line which is carried up above the roof through a pipe shaft alongside of the smoke stack and terminates with an exhaust head.



Power Plant in Sub-Basement of the Commercial National Bank Building.

The piping systems of the plant consist of a ring or loop header for the high pressure steam and two large single exhaust lines for the low pressure exhaust. The high pressure ring main originates in an 18-in. header located 9 ft. above the floor, at the rear of the boiler settings, with 8-in. long-radius pipe bend branches to each boiler unit, valved at both header and boiler nozzles; delivery connections extend up and into the engine-room as a 9-in. loop main and into the pumproom as a 6-in. loop main, the ends of these two loops meeting at the rear of the boiler-room and there being connected to the middle of the high-pressure header by a 9-in. cross connection. The main header is of mild steel with flanged joints and copper gaskets and is designed for 300 lb. test pressure. The loop main is sectionalized by globe valves at the middle and gate valves at either end of the 18-in. main header, and by globe valves so placed in the engine and pump-room loops as to enable all the more important steam-using apparatus to be supplied from either of two different directions, through independent connections from the header. The entire high-pressure line is dripped by a gravity return drip line which parallels the mains and delivers to the boilers through a connection at the rear of the settings. Steam for the auxiliary machinery, including pumps, etc., is supplied from a 6-in. auxiliary header over the boilers that is distinct from the main high-pressure header, being connected to the boilers through the safety valve nozzles; from this header branches extend to the feed pumps, to the hot water heaters for house service, to the vacuum pumps, to the stoker engines, and to the roof for melting ice which may form in the down spouts during the winter, and a 6-in. line to the expansion tank for live steam make-up to the heating system when the exhaust steam supply is insufficient. The exhaust steam system consists of a 16-in. ceiling line in the engine-room and 12-in. line from the pumproom which connect with the steam using units and deliver each independently to the expansion tank at the rear of the engine room, which forms the basis of the low-pressure steam supply to the heating system. Thomas Acme grease extractors in these exhaust lines near the tank remove oil from the exhaust steam.

The steam-using machinery of the power plant consists principally of electrical generating units and the elevator pumps, all of the ventilating fans, the air compressors, the refrigerating machines and other auxiliary apparatus being driven by motors. There are four electrical generating units installed, consisting of vertical compound engines direct connected to Western Electric Co. multipolar generators, two of which units are of 125-kw. capacity, and the other two of 200-kw. capacity, while additional room has been reserved for the addition of another 200-kw. unit if future demands for power should require. The engines are of the vertical cross-compound automatic cut-off type, built by the Bates Machine Co., and are supplied with steam by 5-in. and 6-in. branches respectively, with Cochrane separators, from the 9-in. overhead loop in the engine room, exhausting through 8 and 10-in. branches into the 16-in. overhead exhaust line. The elevator plant of the building embraces 14 passenger and one freight elevator, which are hydraulically operated and require two compound high-duty pumps, which normally take care of the full elevator load, a compound duplex pump of capacity equal to either of the high-duty pumps for reserve purposes and a night pump of half this capacity. The high-duty pumps are Chalmers & Williams cross-compound duplex pumps with Corliss steam valve gear and have 15 and 25x7⅞x24-in. cylinders. There is in addition a jack pump installed for operation in connection with the freight elevator in lifting safes, and machinery, and heavy loads.

Heating System.—The building is heated throughout, above the first floor, by direct radiation, for which a total of 51,463 sq. ft. of direct radiation has been installed, exclusive of the tempering coils of the fresh air supply systems, the fresh air supply being raised to the temperature of the interior of the building before delivery. The radiators, supplied by the American Radiator Co., are installed in the usual locations under window sills, a standard arrangement having been adopted embracing two units to each wall panel of three windows, which is found to most easily accommodate the sub-divisions of floors into various office groups. The standard distribution is one 48 sq. ft. and one 24 to 30 sq. ft. radiator to each panel of three windows, the larger radiator being installed where partitions come so as to limit one unit to two windows, and the smaller unit where only a single window is served. The radiators are installed in general in 26-in., 2-column units, excepting in the first, second and third stories, where 32 and 38-in. 2-column radiators are used, and in the main entrances, where 44-in. 4-column units are installed. Sky-light exposure is encountered to a considerable extent only above the main banking floor, where at the fourth floor level, a 58x92-ft. skylight fills the area at the base of the light and ventilation court between the two upper wings of the building; this glass exposure is counteracted by 28 pipe coils of 1¼-in. pipe, each coil containing 50 sq. ft. of surface. Radiation in all parts of the building is proportioned to maintain temperature to 70° Fahr. when the outside temperature is 10° below zero, for which an average of 2,450 sq. ft. of radiation has been installed on each of the floors above the first. The first floor contains 3,196 sq. ft. of radiation, including that in the entrances, while the skylight coils have 1,400 sq. ft.

Steam is supplied on the one-pipe system to all of the radiation above the first floor by an overhead distribution system, which consists of mains in the attic and down supply risers, while the radiation on the first floor is supplied independently by a system of distributing mains on the basement ceiling. The low pressure heating supply originates as above stated, in the expansion tank into which all exhaust steam from the power plant is delivered. From this a 6-in. connection extends to the basement distribution system for supply to the first floor radiation and a 16-in. supply main to the attic to supply the overhead distribution system. The latter supply main is carried up a pipe shaft alongside of the smoke stack enclosure at the rear wall of the building to the attic space above the eighteenth story, and there connects through an expansion loop to a system of horizontal distribution mains, which divides into a number of branches of 6 and 8-in. mains that supply different groups of risers along the various side walls of the building. The 6-in. basement supply main supplies radiation on the first floor only, tapering to 5 in. and thence to 3 in. in size as branches are taken off. Other steam supply connections from the expansion tank consist of a 5-in. line to the skylight coils above the main banking floor, an 8-in. line to the tempering coils of the fresh air supply systems, and a 7-in. connection to the hot water heaters of the plumbing service. The exhaust steam supply to the expansion tank from the steam-using machinery is supplemented by a 6-in. connection from the auxiliary high pressure steam header in the boiler room with two Davis pressure reducing valves. One of the valves adjacent to the high-pressure header, reduces the pressure of the live steam supply from the boiler pressure of 150 lb. to 15 lb. and the other next to the expansion tank reduces from 15 lb. to atmospheric to augment the low pressure supply automatically in case of deficiency of the exhaust steam. A feature of the low-pressure piping connections is to be noted in the use of a separate 16-in. riser to the top of the building for purposes of atmospheric relief to the exhaust steam system in case of back pressure, instead of utilizing the main 16-in. supply riser to the overhead heat distributing mains; the back pressure valve is here located at the expansion tank, from which the atmospheric relief riser is carried up above the roof through the pipe shaft alongside of the 16-in. steam supply riser and terminates with an exhaust head.

The down-feed risers supplying radiation on the upper floors are 80 in number, the greater part of which are 2½ in. in size, and supply from 440 to 700 sq. ft. of radiation each, the average amount supplied from each 2½-in. line being about 500 sq. ft. There are 62 of the 2½-in. risers, while of the remainder two are 4-in. lines, seven are 3-in. lines, and nine 2-in. lines; these all decrease in size toward the lower floors as radiator supply branches are taken off, the greater part of them being carried down to the basement as 2-in. lines, with the exception of the 2-in. risers, which decrease to 1½ in. at the base. The 4-in. and 3-in. risers occur principally in the corners of the building and exposed locations and carry 750 to 1,240 sq. ft. of radiation each, the average amount carried per 3-in. riser being about 850 sq. ft.; the 2-in. risers are used behind the elevators on the Clark St. side and in certain locations on the upper floors, and carry on an average about 300 sq. ft. each. Owing to the length of the risers, approximately 270 ft., they are all erected in four sections with anchorages to the building structural work at midpoints of each section and expansion loops or joints midway between anchorages; the expansion joints or loops occur at the fourth, tenth and sixteenth floors in each riser, while the anchor points for the sections thus formed occur at the second, seventh, thirteenth and attic floor levels. Wherever possible the loop type of expansion joints was provided for, but in a group of five 2-in. risers at the rear of the shafts of the six elevators rising from the Clark St. entrance, lack of space necessitated the packed sleeve type of slip expansion joints. As the radiation is operated on the one-pipe system, all radiator branch connections are given a uniform slope from the radiator to the riser against the flow of steam and are so located that they cannot be trapped by movement of the riser in expansion; these radiator branches are of 1¼-in. pipe for radiators up to 50 sq. ft., 1½-in. pipe for units having between 50 and 85 sq ft., while 2-in. pipe is used to supply all units up to 120 sq. ft. All of the low-pressure piping and risers are covered with H. W. Johns-Manville moulded asbestos sectional covering, ¾ in. in thickness, the covering extending on all risers from cups provided to support it up inside of the floor sleeves above; all exposed risers are covered with air-cell covering.

Condensation returned from the radiation is collected by two systems of gathering mains on the ceiling of the basement, one of which connects with the bases of the down-feed risers, and the other with the steam supply mains in the basement to supply the first floor radiation. The former is installed in three divisions, each consisting of a 6-in. line connecting with risers in different sections of the building, while the latter is laid out in two sections, one a 3-in. line extending to the front part of the building, and the other a 1½-in. line to the rear. Other condensation return connections consist of a 4-in. return line from the tempering coils of the fresh air supply fan systems, a 3-in. return from the skylight coils, and a 1-in. return from the downspout heads to which high pressure is supplied at the roof. These returns all connect into the 8-in. condensation header in the boiler room, which has a 4-in. connection from either end to the two open feed water heaters. All of the return lines have check valves near the header and between these and the header, gate valves. To insure positive circulation of steam in the heat distribution mains the Paul vacuum system has been installed, consisting of a system of air piping, connecting with the air valves on all radiator units and terminating in the boiler room where connection is made to the usual exhauster apparatus used with this system. The air piping system has been extensively sub-divided so that the shutting down of a portion of the apparatus will not interfere with the successful operation of the remainder, and connections are also made from this system to the feed water heaters and hot water heater to prevent air binding in them. The heaters are also arranged for operating in summer time when the heating equipment is not in use.

The mechanical plant was designed by the architects of the building, D. H. Burnham & Co., of Chicago, under the direction of Mr. John D. Small, chief mechanical engineer. Thomas & Smith, Chicago, were contractors for the heating system and power plant piping, and designed the details.

(To be continued.)

The Soft-Coal Producer Plant at Pasco, Wash.

The town of Pasco is a division point on the Northern Pacific Ry., and is located near its crossing of the Columbia River. At present there are about 1,000 inhabitants, one-half of whom have located there during the last eighteen months. The Pasco Light & Water Company, composed chiefly of Spokane men, has installed a gas producer plant to furnish to the town both water and light and some small quantities of power.

The water obtained from wells in this region is markedly alkaline, and is undesirable for use in steam boilers. The Light & Water Company pumps its water from the Columbia River and delivers it to the town and to the tanks of the railway company. The question of track convenience and franchise stipulations made it necessary to place the power house near the railway yards, close to the town. On the other hand the pumping station is located as near the river as high-water conditions permit.

The power house is a frame structure boarded up with rustic finish on the exterior; the engine and dynamo room is ceiled to protect the running parts as much possible from the fine sand and grit which is carried by the winds in the dry season.

As shown in the plan, the power house is compactly arranged. The producer is of the suction type, built by the Smith Gas Power Company especially for bituminous and lignite coal. A sawdust purifier is added as an extra precaution to prevent carrying over tar to the engine. This is a Rathbun three-cylinder vertical type gas engine of 100 h. p. capacity. It is belted to the generator, a General Electric 75 kw. three-phase alternator, operating at 2080 to 2300 volts and 60 cycles per second. The exciter has a capacity of 3.5 k. w. and is belted to the generator.

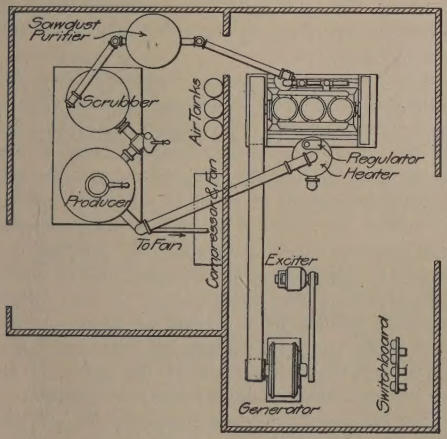
The switchboard consists of two standard panels of the General Electric design. One is the generator panel equipped with three alternating current ammeters, one alternating-current voltmeter with potential transformers, receptacles and plugs, a direct-current field ammeter and switch, exciter rheostat and control for the generator rheostat and oil switch. The other is a two-circuit feeder panel equipped with one ammeter and an oil switch for each circuit. One side of this panel controls the lighting circuit, which is three-phase three-wire primary and single-phase three-wire secondary, 115 volts. The other side controls the pump circuit, three phase 2080 volts.

The pump house is situated on the river about 7,400 ft. from the powerhouse. A 40 h.p. three-phase induction motor directly on the line at 2,080 volts operates the pump. The line consists of three No. 8 B. & S. hard-drawn bare copper wires spaces 14 in. between centers. The pump is a submerged triplex with a capacity of 400 gal. per minute. It is mounted as shown in the illustration at the bottom of a concrete well and the motor operates the working head above by means of a belt.

A test was made of the plant immediately after its installation. The proper load was put upon the generator by means of a water rheostat to give the engine its full rated load. For a portion of the time the plant was operated at part load only, running the pump to fill the pipes. This load varied from 22.1 to 29.5 h.p. as the head in the pipes increased. The test lasted seven hours and showed the consumption of 696 lb. of coal for 512.9 h.-p.-hr., or 1.35 lb. of coal per h.-p.-hr. The local cost of coal brings the fuel cost per h.-p.-hr. to about 0.3 cent. The coal used was a washed lignite nut coal and contained considerable earth and clay.

Book Notes.

The British Fire-Prevention Committee, 1 Waterloo Place, London, has issued a "red book" describing tests of a hydrant fitted with an "adaptor" for automatically putting the hydrant into action. The "adaptor" is described as a device whereby any fire hydrant, cock or tap may be made automatic in action, enabling an operator, by simply grasping the hose attached to the device and running with it to the scene of a fire, to have at hand a supply of water without the necessity of unscrewing the valve in the ordinary manner. The construction of this device, which is made by W. Featherstone & Co., Rochester, England, is illustrated in the report. The "adaptors" tested were fitted to 1-in. and 2½-in. hydrant valves, the water supplied for the smaller hydrants being under a pressure of 8 to 25 lb. per square inch, that for the larger valves varying from 40 to 45 lb. Seventeen tests were made in all, which are fully described in the report.

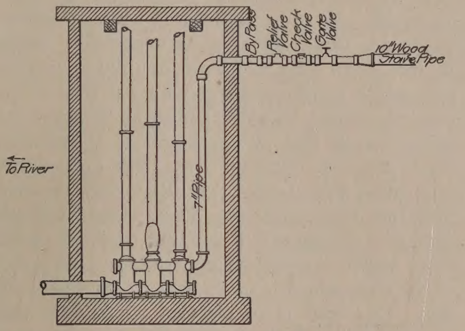


Plan of Producer Plant at Pasco.

The excellent manual on "Stereotomy" by Profs. A. W. French and H. C. Ives has been so successful that a new edition has been prepared, in which the typographical errors of the first edition have been corrected and a number of changes made. The book is one of those practical manuals equally useful in the classroom and the engineering office. The authors state that they have drawn their material from previous books, but they deserve credit for making such good use of it and for the well-selected examples of actual structures that are used for illustrating the principles and methods explained in the text. The book is essentially a description of the procedure to be followed in designing the stone work of all kinds of engineering and architectural structures, and the instructions for preparing templates and drawings are thoroughly practical. (New York, John Wiley & Sons, $2.50.)

An excellent book on the most important machine tool and its uses is "Modern American Lathe Practice," by Oscar E. Perrigo. It gives an outline of the evolution of the tool, describes its use for various classes of work, and illustrates the different types of lathes used in American shops. A gratifying feature of the volume is the absence of catalogue pictures, for every illustration was made specially for the book. There are five chapters on lathe design, two on lathe work, two on engine lathes, and others on lathe attachments, rapid change-gear mechanisms, lathe tools, tests, heavy lathes, high-speed lathes, special lathes, regular turret lathes, special turret lathes, and electricall driven lathes. The book is a comprehensive treatise of reliable character and will be found of value by all who are interested in its subject. (New York, Norman W. Henley Publishing Co., $2.50.)

While a large amount of information is available concerning the engineering features of heavy electric traction on railways previously using steam locomotives, such installations are so recent that practically nothing has been published concerning the operation of these lines. Accordingly the 190-page book on the subject forming a section of the "Street Railway Journal" of Oct. 12 is a unique volume. A careful study was made of the methods used on the New York Central & Hudson River R. R., the Long Island R. R., the West Jersey & Seashore R. R., the West Shore R. R., the New York, New Haven & Hartford R R., the Erie R. R., and the Interborough Rapid Transit Co., and Mr. Philip Dawson contributed an article on what has been done in England and on the Continent. This information will be of great value not only to the officials of steam railways who are contemplating electric traction, but also to the managers of electric traction companies The latter have worked out their problems along certain lines, but as the high-speed electric road is the outgrowth of the city line it is not surprising that the conclusions reached by their officials differ from those obtained when the same questions are taken up from the steam railway standpoint and when the electric railway is operated as part of a large trunk line. The book is beautifully printed and profusely illustrated, and is an unusually important contribution to the publications on heavy electric traction. (New York, Street Railway Journal.)



Concrete Pump Well of Pasco Plant.

Some day a great novelist will awake to the possibilities of irrigation as the central theme for a powerful story, and people will be amazed to learn from him what a tremendous influence it plays in every-day life in some sections. The facts are all at hand for him, in the dry statistics of government reports, in the laboriously deciphered hieroglyphics of the Pharaohs showing that upon it depended the glory of their dynasties, in the translations of Hammurabi's cuneiform inscriptions proving that it was perennial irrigation which made ancient Chaldea a great nation, and in the writings of Sir William Willcocks and others who have not only taken part in the great national irrigation works of to-day, but have studied those of the ancient nations. It is a fascinating study as a factor in civilization, wholly apart from those technical features that appeal only to the engineer, and it is noticeable that engineers who have played an important part in great irrigation undertakings, in their books on the subject generally introduce unknowingly a certain flavor of special interest on account of the intimate relation between works and striking results that marks such enterprises. The great Chenab canal in India, for example, has turned some two million acres of waste land in India, on which a very small nomadic population existed precariously, into the bountiful home for a million people. This special feature of books on irrigation is marked in Sir Hanbury Brown's "Irrigation; Its Principles and Practice as a Branch of Engineering." The author's long service in such works in India and Egypt enables him to speak as one having authority and not as the scribes. In setting forth the subject he has drawn on this knowledge, particularly that gained in Egypt, for illustrations and examples, and the result is a book of deep interest, particularly at this time, when irrigation in the United States is at last beginning to receive due recognition. To engineers, the great merit of the book lies in the fact that it is on irrigation, and the design of high dams, and other works of a special character is left to treatises on such subjects. It opens with a chapter on what irrigation has done and is doing in many countries, and the subject is handled in a way that arouses regret that this part of the book was not published in some magazine of wide circulation, for the information of the general reader. The essential features of basin and perennial irrigation are pointed out in two chapters, and there are some notes on the "duty" of water, introduced at this place in order that this important feature of irrigation work may be understood at the outset. The author uses the term to indicate the amount of irrigation water ought to accomplish and not what it actually does in any case, thus giving the word a more restricted significance than it usually has in the United States. The fourth chapter, on sources of supply whence water may be obtained, contains some interesting notes on India's irrigation methods and the extent to which it is possible to extend irrigation in Egypt, given to illustrate the general principles laid down. A chapter on dams and reservoirs is introduced next, in which the author deals mainly with the purposes of such works and their general features. It is followed by one on weirs and barrages, containing a large amount of interesting information concerning works of this nature in India and Egypt. In building many of these works unusual conditions were encountered and a chapter on methods of construction is given for the purpose of bringing together in one place all notes on the subject; these relate mainly to foundations, and the account of the methods on constructing dams and weirs on gravel, clay and sand foundations deserves special attention. The chapter on canals and drains is particularly interesting for the emphasis laid by the author on the importance of providing means for draining the irrigated land as well as for bringing water to it. An omission to make any reference to methods of lining canals to prevent seepage seems rather surprising to an American reader on account of the special interest shown in the subject in the United States at the present time. The various masonry works along the line of irrigation canals are described in a chapter explaining the purpose of regulating works, fall, syphons and aqueducts, illustrations of notable structures being given. The methods of distributing water, assessing the charges for it, and of administration in various countries are explained in one of the most instructive chapters in the book, and it is interesting to learn from it how universal has been the experience that some measure of public control over water for irrigation is necessary. Two chapters are devoted to flood banks, river training and navigation, and there is a particularly good chapter on agricultural operations and reclamation works. The book as a whole is particularly timely for American readers and should prove of much value to those who desire a general knowledge of irrigation. (New York, D. Van Nostrand Co., $5.00.)

Letters to the Editor.

Misuse of Derrick Cars.

Sir: An accident that took place about a fortnight ago during the erection of a bridge on the Nickel Plate road over the Cuyahoga River again calls attention to a grave misuse of derrick cars often made. In this particular case a 50-ton car was being used to lift a pedestal weighing about 10 tons. It was raised and then the boom of the derrick swung around to the side. As it swung, the car tipped slowly but steadily to such a degree that those nearby were alarmed and shouted to the men on the car to turn the boom back again. They continued to revolve it, however, and suddenly the car was overturned off the deck span on which it was standing, and the men were killed in its fall.

It would hardly be worth while calling attention to this accident were it not for the fact that bridge erectors are constantly taking chances of this sort. A few months ago an unusually powerful derrick car was built for handling very large girders. It was a special machine and the designer naturally watched its operation during the first few days it was in service. Although he had perfect confidence in the car, the manner in which it was employed in lifting high loads at right angles to the track on which it stood filled him with serious apprehension, and as a result he warned the owners of the car in writing against attempting any such feat. Even when a derrick car is supported by jacks under the outstanding arms on either side, its base is so narrow that a heavy load lifted far out on either side is likely to overturn it. No trouble is experienced in lifting such loads ahead of the car on account of the long wheel base, and the freedom from trouble when the boom is in such a position is likely to cause an unwarranted feeling of safety in the ability of the car to stand up when lifting heavy loads at the side of the track. I think it would be well for your journal to call attention to this dangerous condition.

Very truly yours,

Erector.

Conditions on the Isthmus of Panama.

Sir: Your little note in your issue of last week concerning the conditions at the Isthmus of Panama is interesting to me, for it shows that the official reports contained in the "Canal Record" are appreciated in your office. Fortunately the grumblers at the Isthmus have now been largely returned to the United States, whence they never should have gone to take part in canal work. It is a fact that the conditions on the Isthmus are by no means those to which a number of the younger engineers and other employees were accustomed. They went to the Isthmus evidently expecting it to be a sort of glorified picnic ground. They were disappointed and in some cases their families were put to much inconvenience. These people have all very naturally expressed their adverse opinions of the conditions. On the other hand those of us who have been accustomed to work in the field in different parts of the United States have almost without exception been satisfied with the manner in which the government is endeavoring to make us comfortable. The line of the ditch is a good ways from home and it takes money and men to build houses and carry on large camps. It also takes time, and inability to appreciate the importance of this last factor is the primary cause of most of the complaints that were formerly current concerning the canal work.

Where new work is being started it goes without saying that the accommodations for some of the men are naturally cramped. This is so on every large piece of construction with which I was ever acquainted. I have been forced to sleep under shacks many times while camps were being constructed, and accordingly the temporary accommodations provided on the Isthmus on new work did not seem at all out of the ordinary, except as they were somewhat better than those that are usually provided in the States. Nevertheless, some young men, whose experience on construction had been obtained wholly in connection with municipal work, considered themselves terribly abused by being obliged to sleep in cramped quarters for a few weeks. I noticed that it did little good to endeavor to explain to them that the conditions were only what they would encounter in the United States under similar conditions, for out of their experience in the vicinity of cities where plenty of quarters was always available, they have proceeded to criticise everything that has been done for their comfort in a very silly manner.

In the camps that have been established for some time, the accommodations have been far better than those provided by the average contractor, while the attention paid to sanitation is really remarkable. The medical supervision of all the men leaves nothing to be desired, and any engineer who wishes to become familiar with construction under tropical conditions and is not afraid to live away from the bright glare of the electric lights along Broadway cannot do better than to join our force. We have plenty of opportunities for recreation, and various amusements are being arranged as opportunity arises. In fact, from all I can learn, the only organization which at all compares with our own in the general attempt to get together in the most sociable way is that of the Board of Water Supply of the City of New York. Our organization is a good deal larger than that, and naturally there are more grumblers in it. I doubt if you ever saw an organization of 250 people in which there was not more or less jealousy, and a few of the class which is never happy without grumbling. Our staff is so big that we have a good many of these people; we are accustomed to them and pay no attention to them, for we know that they are not happy without grumbling, and many of them are otherwise good fellows and work hard. But the kicks they make are apparently misunderstood among the people at home, and it is for this reason I am sending you these few comments.

Very truly yours,

On Leave.

Impermeable Concrete.

Sir: Your editorial discussion on impermeable concrete in the issue of Oct. 19 is interesting to the writer on account of the strong intimation it gives regarding the usefulness of a certain amount of clay in concrete mixtures. This is a subject that has been debated so much of late that until really accurate experimental work is carried on, such as that which Mr. Gaines is evidently conducting, the view that any engineer will take of it is likely to be based on his personal predilections and limited observations, rather than on any careful sifting of all evidence. It will doubtless be recalled by many who had an opportunity to hear the discussion of the subject at the Asheville convention of the American Society of Civil Engineers that the use of alum and other substances has been adopted successfully to render concrete watertight, while some engineers have long claimed that a moderate amount of clay was of value for the same purpose. There is, of course, a great difference in the qualities of clays and consequently statements regarding this material have to be accepted with a mental reservation in each case that the term covers such a wide variety of substances that the information is of only very general value.

I do not recall that any experiments prior to those of Mr. Gaines have been made to ascertain the effect of a combination of alum or some other similar substance and clay with the regular concrete materials. In fact it may be questioned whether the experiments on which Mr. Gaines has based his statements in the "Transactions" of the American Society of Civil Engineers have been carried far enough, and my own belief is that it is very desirable in investigations of this nature to defer the drawing of any precise deductions from such results until the experiments have included many series of tests which vary between themselves by a modification of only one or two factors, so that the effect of changes in those factors can be fully determined. It seems to be true, however, that the use of alum and clay under certain conditions may yield a very watertight concrete, and there are other substances for which similar claims can be made. Hence I would suggest that it might be advisable for you to discuss the extent to which impermeable concrete of this character can be safely applied. We can all agree with your statements that waterproof concrete is highly desirable material for engineering purposes, but it seems to me that in any discussion of this nature it is very desirable to bear in mind that waterproof concrete is, after all, concrete, and must be regarded like any other artificial stone.

The investigations that are being made by Mr. Gaines are evidently conducted with a view to ascertaining, among other things, the availability of various substances to render concrete in long aqueducts impermeable. Aqueducts are generally sufficiently covered by earth or otherwise protected against the weather to be free from any material changes in temperature. The problem presented by concrete under such conditions is very different from that presented by a long retaining wall holding back a bank of earth or loose rock likely to be fully saturated with water during a considerable portion of the year. In the former case there is no tendency to crack, while in the latter there is every tendency for cracking to occur. In the former case water is likely to cause trouble only by percolating through interstices of the concrete. In the latter case the temperature changes are likely to cause fissures into which considerable quantities of water may enter and there freeze, causing a bad shattering of the concrete in numerous places. Consequently it is manifest that the problem of water-proofing in the two situations is wholly different. I mention this difference because it seems to me that there may be a tendency to require impermeable concrete for situations where other water-proofing is a far better protection. It has long seemed to me that where long concrete walls or floors are exposed to the direct outside air and are resting against earth containing water, the only safe water-proofing method lies in the use of some of the so-called "membrane" processes. These have sufficient flexibility to protect the concrete from water even when the concrete becomes cracked.

Between these two extreme cases lie many in which the judgment of the engineer must naturally decide what kind of process must be adopted in order to secure an impervious wall or floor. Unquestionably there are situations where the temperature conditions may render a perfectly stiff and stony material like concrete so free from the likelihood of cracking that water-proofing by rendering it impermeable is safe to use. It is for this reason that the methods are so important and that all investigations of them should be encouraged. Nevertheless, it is far more important for most classes of engineering work to obtain a thorough knowledge of methods of water-proofing concrete which will keep the walls impermeable after the concrete has cracked, for most concrete work with which the engineer has to do is subject to such cracking.

Very truly yours, C. E.